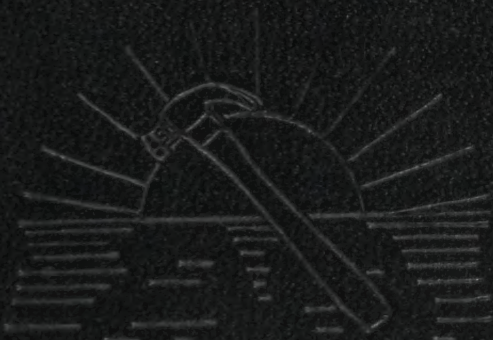
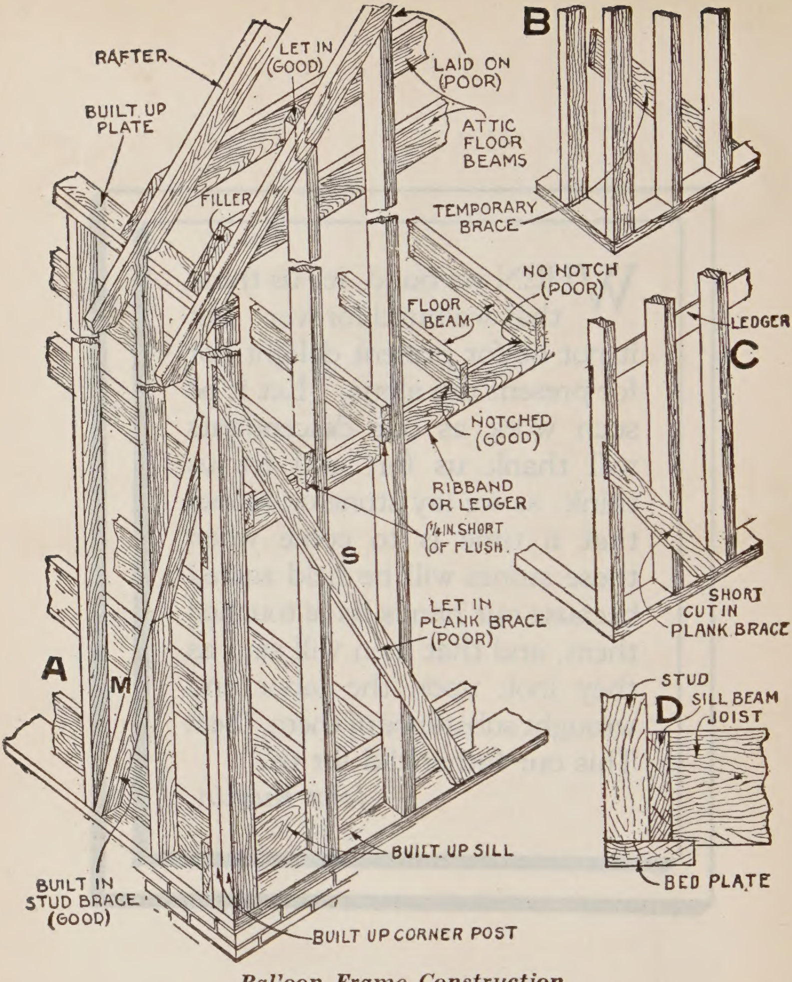
AUDELS CARPENTERS AND BUILDERS GUIDE #3



WHEN we build, let us think that we build forever. Let it not be for present delight nor for present use alone. Let it be such work as our descendants will thank us for; and let us think, as we lay stone on stone, that a time is to come when those stones will be held sacred because our hands have touched them, and that men will say, as they look upon the labor and wrought substance of them, "See! This our father did for us."

—*John Ruskin.*



Balloon Frame Construction

The parts are: **A**, corner of frame showing the various members. **M**, is a substantial built-in stud brace, and **S**, a cheap let-in plank brace. **B**, temporary brace; **C**, short let-in plank brace; **D**, detail of built-up sill.

Balloon frames are probably so called because of their extreme lightness and rigidity, as they embody some of the characteristics of the balloon, including simplicity of construction and uniformity of outline, but basket frames would be a more appropriate name for them, as their construction partakes much of the basket pattern—that is to say, they have upright stays or studs, but wood instead of willow covering.

"BY HAMMER AND HAND ALL THINGS DO STAND"

AUDELS CARPENTERS AND BUILDERS GUIDE # 3

A PRACTICAL ILLUSTRATED TRADE ASSISTANT ON

MODERN CONSTRUCTION

FOR CARPENTERS - JOINERS
BUILDERS - MECHANICS
AND

ALL WOOD WORKERS

EXPLAINING IN PRACTICAL, CONCISE LANGUAGE AND BY WELL DONE ILLUSTRATIONS, DIAGRAMS CHARTS, GRAPHS AND PICTURES, PRINCIPLES ADVANCES, SHORT CUTS - BASED ON MODERN PRACTICE - INCLUDING INSTRUCTIONS ON HOW TO FIGURE AND CALCULATE VARIOUS JOBS

BY

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THEO. AUDEL & CO. - PUBLISHERS
65 WEST 23RD ST., NEW YORK, U.S.A.

Printed in the United States

Foreword

"The Audel's Guides to the Building Trades" are a practical series of educators on the various branches of Modern Building Construction and are dedicated to Master Builders and their Associates.

These Guides are designed to give technical trade information in concise, accurate, plain language.

The Guides illustrate the hows and whys, short cuts, modern ways and methods of the foundation principles of the art.

Each book in the series is fully illustrated and indexed for readiest form of reference and study.

The Guides will speak for themselves—and help to increase the reader's knowledge and skill in the Building Trades.

—*Publishers.*

OUTLINE OF CHAPTERS

READY REFERENCE INDEX

How to Use the Index.—By intelligent use of the index, the reader will have no difficulty in finding any item, and if he will carefully read the index he will be amazed at the vast amount of information to be found in this book, and will in this way find numerous items he would like to look up. This constitutes one method of study—***a reference method.***

The making of an index is an art which requires long experience, the indexes for these Guides being made by specialists in that line.

An index is said to be "full" when each item is indexed in two or more ways. For a practical example, the item "Rip saw," may be indexed either as "Rip saw," or "Saw(s), rip." This method of entering each item in two or more ways constitutes a *full index*.

In the ***Carpenters' and Builders' Guides*** the author has *abridged* the index to gain more space for the main text, by largely avoiding the unnecessary cross indexing.

Accordingly, if you do not find the item "Rip saw" in the letter R, turn over to S, and look for "Saw(s), rip."

In case the item be not found under either heading, look up some *associated heading*, as, for instance, "Tools," and follow down the indented items under this heading, looking for the desired item, "rip saw."

It should be noted that when there is a main heading with comma, followed by indented items, the main heading should be connected with each indented item, thus:

Plane(s), ills., 259-290
    block, ills., 265, 284

the last item being read in full, "Plane, block, 265, 284."

Finally, if an item be not found in one Guide, look for it in the other volumes of the set. For instance, the *steel square* is explained in Guide No. 1, and its application to roof framing treated at length in Guide No. 3.

A

B

C

D

E

F

CHAPTER 35

Laying Out

Selection of Site on Lot.—The term *laying out* here means *the process of locating and fixing reference lines which define the position of the foundation and outside walls of a building to be erected.*

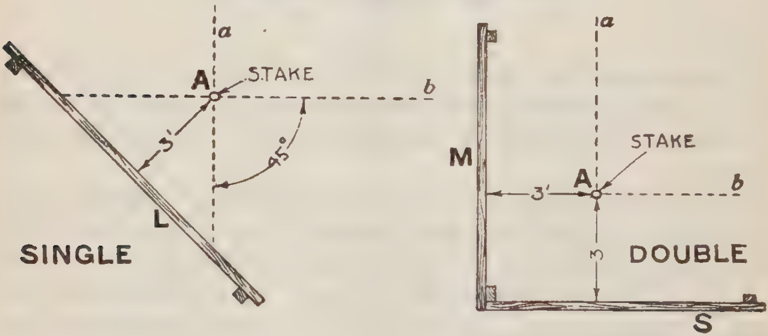
Preliminary to laying out (sometimes called "staking out") it is important that the exact location of the building on the lot be properly selected. This involves a careful examination of the ground to determine the character of the soil which will largely determine its sanitary condition and influence on the health of the occupants. The chief object in this examination is to so locate the building as to obtain a dry cellar. In this examination, dig a number of small deep holes at various points, extending to a depth a little below the bottom of the cellar.

The "ground water" which is always present near the surface of the earth, will, if the holes extend down to its level, appear in the bottom of the holes. This water stands always nearly at the same level, so that it is not met with so near the surface of a slight knoll or other elevation as in the case of a depression.

If possible in selecting the site for the house it should be so located that the bottom of the cellar is above the level of the ground water. This means locating the building if necessary at some elevated part of the lot, or reducing the depth of excavation. It is better to alter plans than to have a damp cellar.

Laying or "Staking" Out.—After the approximate location has been selected the next step is *to lay out the building lines.* That is, the position of the corners of the building must be marked in some way so that when the excavation is begun, the workmen may know the exact boundaries of the cellar walls. There are two methods of laying out the lines:

1. With lay out square.
2. With surveyor's instrument.
3. By method of diagonals.



FIGS. 1,741 and 1,742.—Single and double batter boards. After locating a corner of the proposed building by driving down a stake A, erect either a single batter board as in fig. 1,741, or a double batter board, as in fig. 1,742. Note the general direction of the building lines A*a*, and A*b*, and locate the single board L, or double board MS, 3 feet back of the stake and with posts far enough apart so that the lines A*a*, and A*b*, (produced) will cut the boards at least 30 inches from the posts.

Whereas the first method will do for small jobs, the efficient carpenter or contractor will be provided with an architect's level or transit, with which lines may be laid out with great precision and more conveniently than by the makeshift first method.

The Lines.—There are several lines which must be located

at some time during construction and they should be carefully distinguished. They are:

1. The *line of excavation*, which is outside of all.

2. The *face line* of the basement wall inside of the excavation line, and in the case of a masonry building.

3. The *ashlar line*, which indicates the outside of the brick, or stone walls.

In the case of a wooden structure only the two outside lines

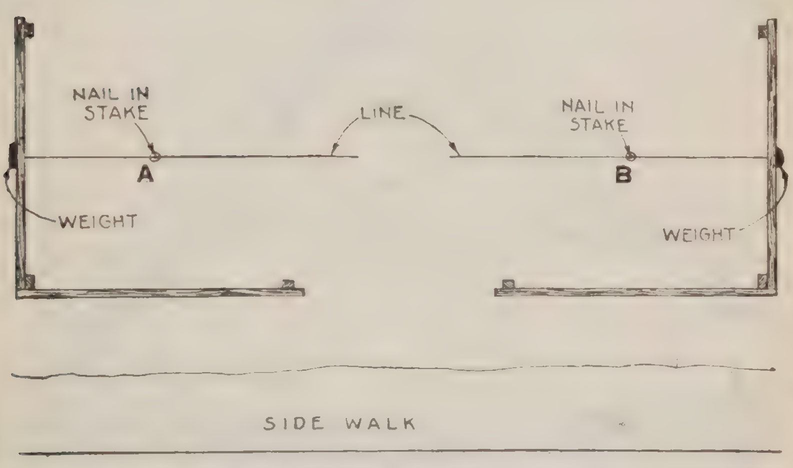


FIG. 1,743.—Location of front line of building. A, and B, are the two stakes with a nail driven in each, the distance between these nails being the length of front side of building.

need be located and often only the line of the excavation is determined at the outset.

Laying Out with Lay Out Square.—Start to lay out from any point on the ground at which it is desired to place one corner of the building, by driving a stake at this point. Back of this

point (far enough to be outside of the excavation line—about 3 ft.) erect a batter board as shown in figs. 1,741 or 1,742.

Suppose that the building is of rectangular shape and that the front of the building is to be parallel with the street.

Starting at the stake A, fig. 1,742 (using double batter boards) lay out a line parallel with the sheet as in fig. 1,743, driving a stake B, at a distance equal to the length of the front of the building. The exact location of the ends of the line may be indicated by a nail driven into each stake. Since

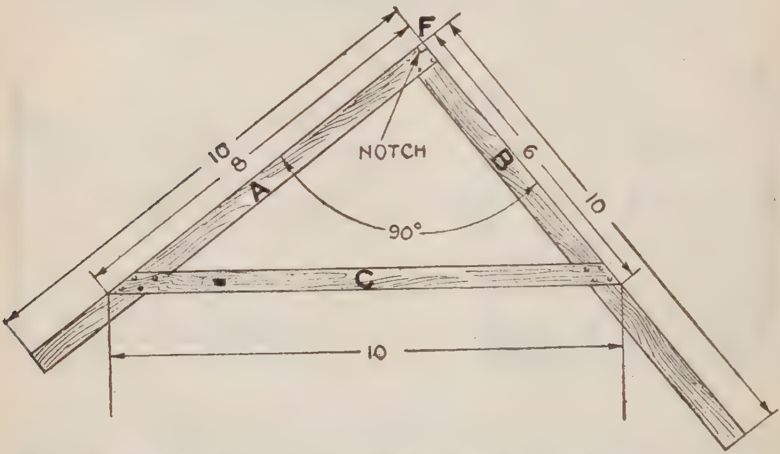


Fig. 1,744.—Large lay out square. ***In construction,*** get three 1 × 6 boards A, B, C, 10 feet long. Square off ends of A, and B, with precision (if this make these boards a little less than 10 feet it does not matter). Mark off with care 8 feet on A, 6 feet on B, and 10 feet on C (if C, be short of 10 feet, get a longer board and mark off accurately 10 feet). Now place A, on top of B, and C, on top of both and fasten with nails. If this work be done with precision an accurate right angle will be obtained at F. A much better job is to make a lap joint at F, so that surfaces A, and B, will lie in the same plane. The square should be notched at F, so the stake will not prevent placing it under the lines.

the building is of rectangular shape lines must be laid out at A and B, at 90° or right angles to the line AB.

The right angle is obtained by means of a large square constructed as in fig. 1,744. The figure shows the right way to make the square by having boards A and B the same length. It must be evident that if A and B be cut off where they are joined to C, making B shorter than A, the extra length

of A does not add to the precision, as the latter depends upon the length of the shortest side. This square is shown in fig. 1,745 at corner A.

In using the square, the legs and lines are brought into alignment by means of a plumb bob. Having thus placed one leg under line AB, line AD, is adjusted on the batter boards until it is directly over the nail in stake A, and the other leg of the square. When the four lines AB, BC, CD, and DA, are thus located and the work checked by measuring diagonals AC and BD, (which must be equal), the lines are located permanently by sawing vertical slits in the batter boards into which the lines are placed. Stakes B,C,D,

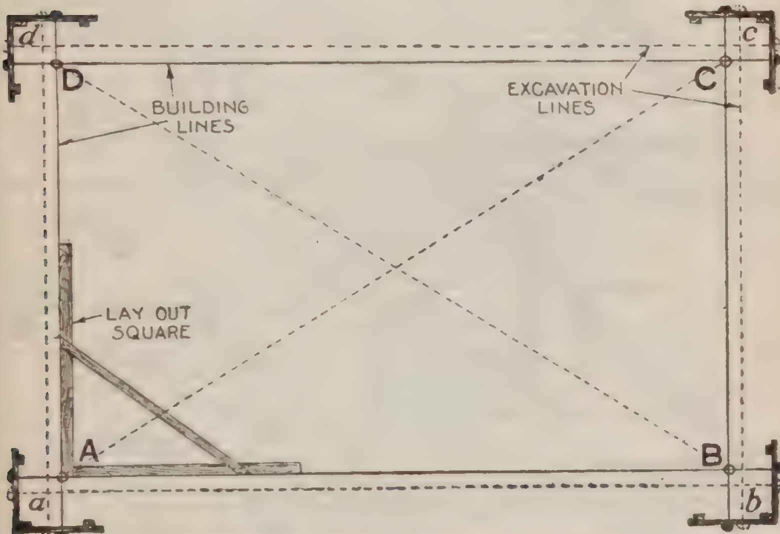


FIG. 1745.—Lay out for building showing batter boards (*a*, *b*, *c*, *d*,) lines and stakes A, B, C, D, in position, also lay out square placed at A, to locate line AD, at right angles to AB.

may now be driven at the corners, using a plumb bob to locate on the ground the intersections of the lines.

Fig. 1,746 shows use of the plumb bob and fig. 1,747 method of permanently locating lines by sawing slits in the batter boards as slits L and M, for lines AD and AB.

After permanently locating the four building lines, mark off on the batter

boards the distance the excavation lines are from the building lines and cut slits at these points, as in fig. 1,747.

In excavating, the lines are placed in the outer or excavation slits, and may be later moved into the other slits as the work progresses. These lines are held taut by means of weights as shown.

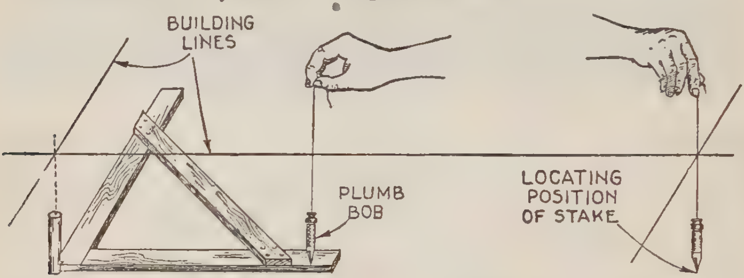


FIG. 1,746.—Method of bringing lines and lay out square into alignment, and location of point for corner stake by means of a plumb bob.

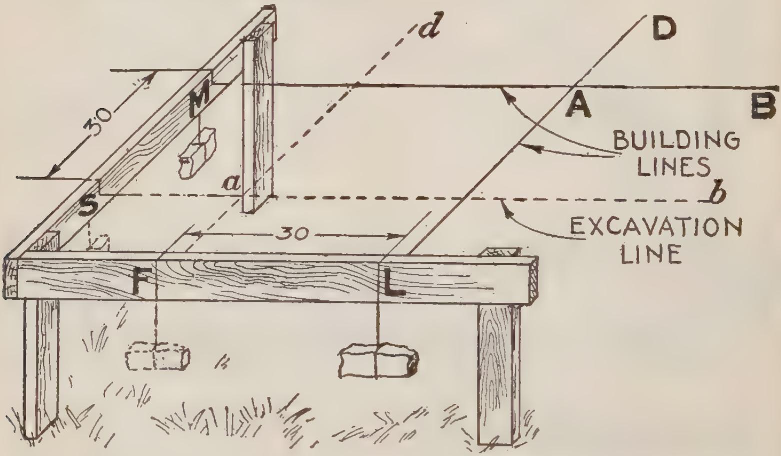


FIG 1,747.—Permanent location of lines by means of slits cut in the batter boards. Slits L, and M, locate the building lines. When the work is first started the boundaries for the excavation must be indicated. These extend some distance outside the building lines. Measure off this distance (say 30 inches) on the batter boards as shown (MS, and LF,) giving points M, and F, at which slits should be sawed. Evidently by placing the lines in these outer slits the excavation boundaries are obtained for the excavation.

Laying Out with Surveyor's Instruments.—The architect's level, or a transit may be used, and as these are instruments of precision the work of laying out is more accurate than where the lay out square is employed.

In fig. 1,749, let ABCD, be a building already erected, and it be required to lay out the site of a building GHJK, at a given distance from and at right angles to, the first building.

Level up the instrument at E, making AE, as shown by the point of the plumb bob below the instrument, equal to the distance the side of the

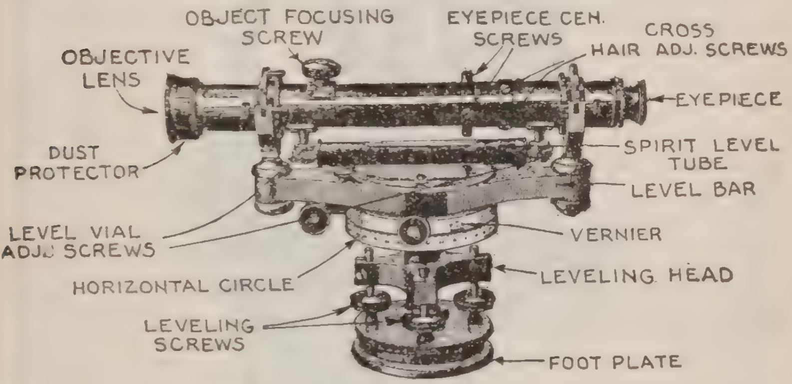


FIG. 1,748.—Contractor's or architect's level. The various parts are named in the illustration. This instrument differs from the transit shown in fig. 1,750 in that it has no attachment for measuring vertical angles. This is not serious, however, since the builder seldom needs such an attachment.

new building is to be from AB. Make BF, the same length as AE, and sight on a flag pole or rod placed on F. Make the vertical cross wire cut the stake exactly and fasten the clamp screw.

Then have an assistant carry the flag pole to G, making FG, the required distance of the new building from the side BC. Have him move the pole from side to side until it is exactly in line with the vertical cross wire. Locate H, on the same line, making GH, the desired length.

Then place the instrument over the point G, and level it up. Focus the telescope on the flag pole placed at E, or F, and fasten the clamp screw.

Turn the horizontal circle until one of the zeros exactly coincide with the vernier zero. Loosen the clamp screw and turn the telescope and vernier to 90 degrees. Any point which the vertical cross wire cuts, as K, will be on the side of the proposed building. GK, may be made the required length. The other side GH, is checked up by turning the telescope until the vernier zero corresponds with the other zero on the circle. If the work has been correctly done, H, will be on the point located before.

The level may be used in setting floor timbers, in aligning shafting, locating drains, in ascertaining the height of springs and the depth of wells.

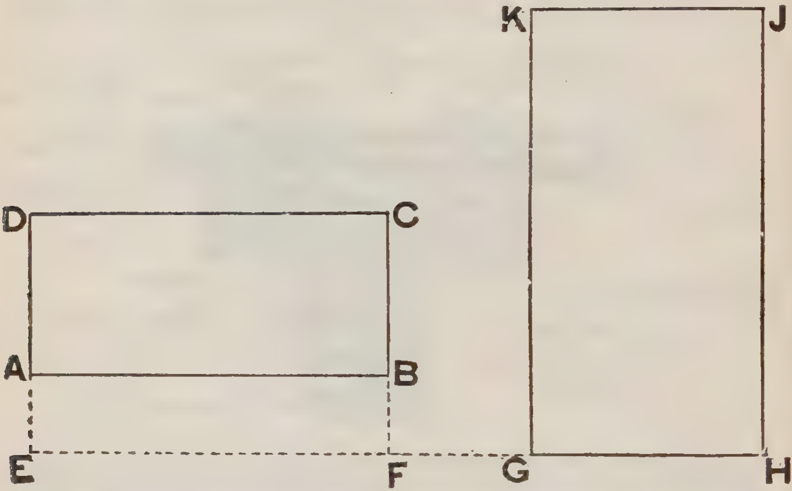


FIG. 1,749.—Diagram illustrating method of laying out with surveyor's instruments.

Method of Diagonals.—All that is needed in this method is the twine for the lines, stakes and a tape measure. Here the right angle between lines at corners of a rectangular building is found by calculating the length of the diagonal which forms the hypothenuse of a right angle triangle with two adjacent sides. By applying the following rule the length of diagonal or hypothenuse is found.

***Rule.**—The length of the hypothenuse of a right angle triangle is equal to the square root of the sum of the squares of each leg.*

Thus, in a right angle triangle ABC, of which AC, is the hypothenuse

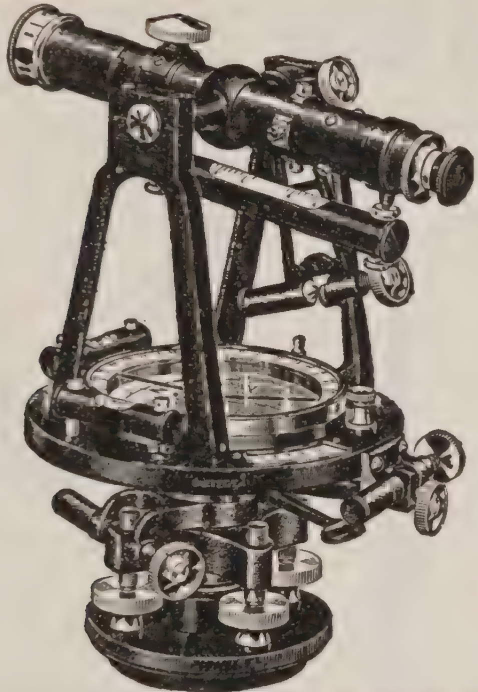


FIG. 1,750.—Dietzgen builders transit. It rests on a tripod and consists of a small telescope with crossed hair wires within, by means of which the observer may fix the line of sight very accurately. A circular dial contains a magnetic needle which enables the fixed dial to be set with reference to the true north and south line of the observer. After the fixed dial has been adjusted, the telescope may be swung to the right, or left, until the circular graduations indicate that it points in the direction wanted, after which stakes may be set.

$$AC = \sqrt{AB^2 + BC^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This is very simple to apply. Suppose in fig. 1,752, ABCD, represent the sides of a building to be constructed and it be required to lay out these lines to the dimensions given. Substitute the values given in equation (1) thus:

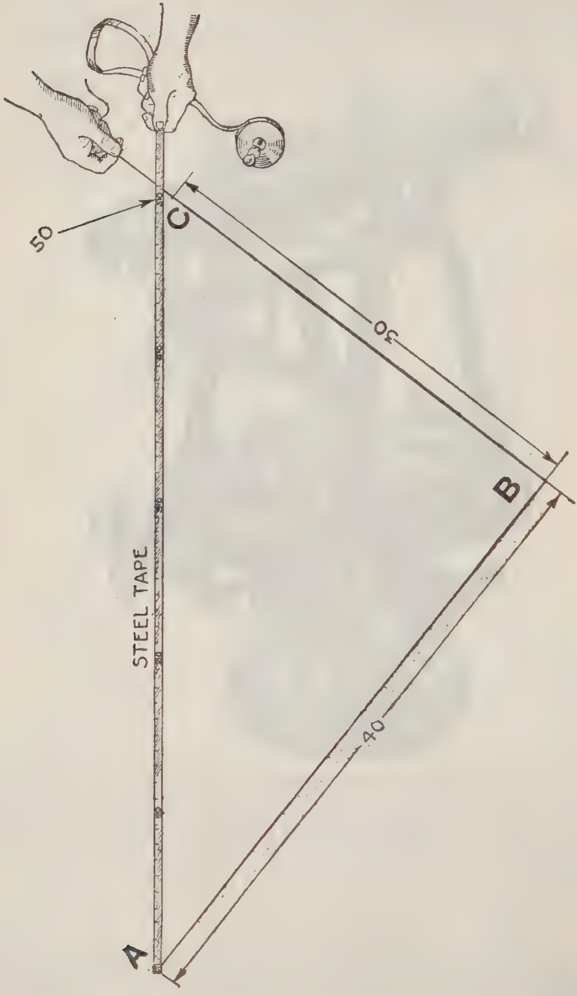


FIG. 1,751.—Method of laying out lines for a rectangular building by aid of diagonals. This is virtually the process of constructing a large layout square, using lines and steel tape in place of boards.

$$AC = \sqrt{30^2 + 40^2} = \sqrt{900 + 1600} = \sqrt{2500} = 50$$

To lay out the rectangle of 1,752, first locate with stake pins the 40 ft. line AB.

Attach to B, the line for the second side and measure off on this line the distance BC, or 30 feet, the point C, being indicated by a knot. This distance must be accurately measured with the line in the same tension as when later adjusted.

With end of steel tape fastened to stake pin A, adjust positions of the

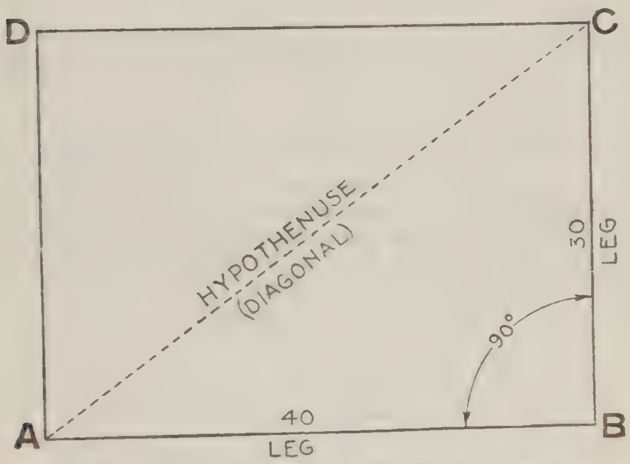


FIG. 1,752.—Diagram illustrating how to find the length of the diagonal in laying out lines of a rectangular building by the method of diagonals.

tape and line BC, until the 50 foot division on the tape coincides with point C, on the line, then will ABC, be a right angle and the point C, properly located.

Proceeding in a similar manner, lines for the other two sides of the rectangle are laid out. After thus obtaining positions for the corner stake pins, erect batter boards and permanent lines as in fig. 1,747.

Points on Laying Out.—In most localities it is customary for the carpenter to be present and to assist the mason in laying out the foundations. Upon ordinary residence work a surveyor is employed to locate lot lines.

Once these lines are located, the builder is able to locate the building lines by measurement.

A properly prepared set of plans will show both the present lay of the ground upon which the building is to be erected, and the new grade line which is to be established after the building is completed.

The most convenient method of determining old grade lines and of establishing new ones is by means of the transit, or the Y level with the rod. Both instruments work on the same principle in grade work. As a rule the mason has his own Y level and uses it freely as the wall is constructed, especially where levels are to be maintained as the layers of material are placed.

In locating the earth grade about a building, stakes are driven into the ground at frequent intervals and the amount of "fill" indicated thereon.

Grade levels are usually established after the builders have finished, except that the mason will have the grade indicated for him where the wall above the grade is to be differently finished from that below. When a Y level is not available, a 12 or 14 ft. straight edge with a common carpenter's level may be used, using stakes to define the level.

CHAPTER 36

Foundations

According to the Building Code, the term *foundation* includes all walls, piers or other supports below grade or curb levels. The proper construction of any foundation depends entirely upon conditions and the architect's plans, presuming, of course, that their plans are properly prepared.

Foundations are only treated here in a general way, but at greater length in later chapters dealing with the particular materials entering into their construction. There is a multiplicity of ways in which foundations are made and various materials are used, such as, wood, concrete, brick, stone, etc. The particular kind of foundation best suited for a building depends upon the nature of the earth and other conditions.

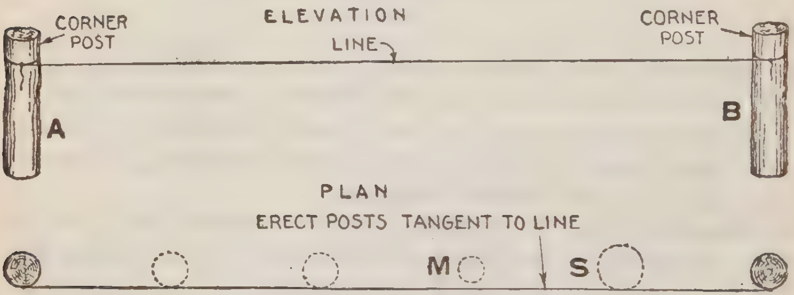
It is not often that the builder must determine sizes as, in most instances the plans come to him with all sizes detailed and marked, but, in the event of his coming upon conditions not discovered by the architect he should be qualified to speedily discern how to overcome them and proceed with the work in a proper manner.

Timber Post Foundations.—The wooden post or pile is the simplest and cheapest form of foundation for light frame building, tool houses, shops, bunk houses, bungalows and such like, on account of its handiness, ease of obtaining, rapidity of handling and placing and economy of time and material.

The posts should be selected from the branches or trunks of locust, chestnut, cypress or oak trees, if possible. They should measure not less than 6 inches in diameter at the smallest butt or end and they should be well seasoned, without checks, twists or sap, and be straight and sound in every respect.

It is a good rule to sink the posts into holes dug not less than 3 ft. deep.

Three and one-half feet is better as the post in winter time, especially in



FIGS. 1,753 and 1,754.—Method of lining up posts in constructing a post foundation. Locate and place in position two corner posts as A, and B. Stretch a lay out line between these posts so that it is tangent on the outside as in fig. 1,754. The posts to be erected between A, and B, should be placed tangent to the lines as shown by the dotted circles in fig. 1,754. In the case of a small post as M, it may be moved in from the line a little so that the centers of the posts will be in line. An unduly large post as S, however, should not project outside the line but be simply tangent to it.

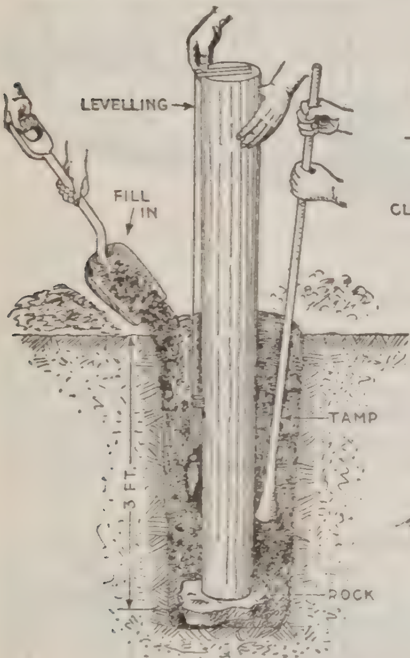
the very cold northern climates, invariably penetrates at least 2 feet 6 inches or 3 feet into the ground, which must of necessity thaw and soften when the warm spring weather returns; so that the bottom ends should rest on solid ground or stone, so that they will not become loose, sink nor move, when mild weather comes.

Fig. 1,755 shows the method of erecting a post.

If the ground or site for the proposed building be comparatively level, this will be an easy task and the piles or posts may be of the same length but if it be sloping or of a hilly character, then the posts must be supplied longer, and set to suit the grade as represented in fig. 1,757, in which it is seen for

this particular location the ground dips to such a quick pitch that the seventh or last post to the left is two and one-half times longer than that to the right, but the average length of the posts inserted below the ground's surface or depth of 3 feet of the holes is still maintained.

If obtainable, good flat stones equal to the diameter of each post hole, might be laid in the bottom and the post ends surrounded with small stones, before filling in the soil, which should be done gradually, each shovel full



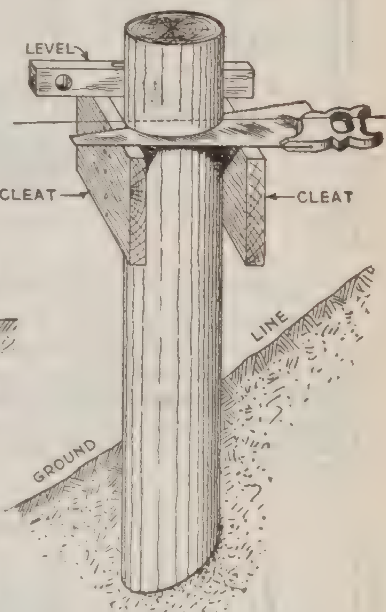


FIG. 1,755.—Method of erecting a post. Note the large rock placed at the bottom of the hole; the post being plumbed from all sides with plumb bob and the earth being thoroughly tamped down as the hole is being filled.

FIG. 1,756.—Method of sawing off top of post using cleats to guide the saw.

first being thoroughly rammed and tamped down solid, at the same time keeping the post plumb all the way around, which can be done by walking to different sides of it, using either a plumb bob and string or if experienced, it may be experienced "by eye"

In addition to setting the post on a flat stone excellent results have been obtained by taking the bark off the post and even roughing it a little at the bottom and first putting in about 12 inches of fill with concrete. This so anchors it that it is not lifted by the gripping frost, as has been known to be the case. Posts other than locust or heart cedar should be barked and treated with a preservative such as painting with asphaltum tar.

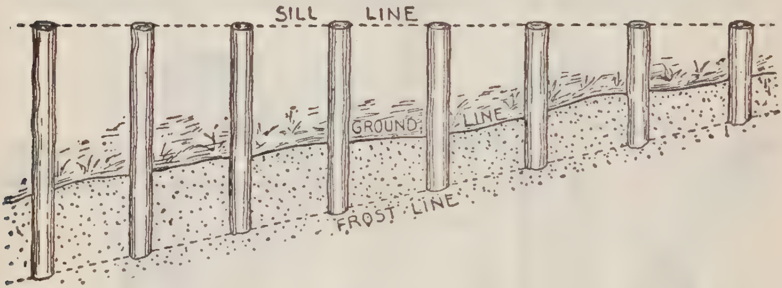


FIG. 1,757.—Line-up of posts erected in sloping ground.

Rows or long series of posts, in fact those of more than three should be set to a line or straight edges to preserve their straight alignment, and, in order that the timber sills set on top of them should rest on each and every post as near the center as possible and have full bearing support. They must also be sawn off to the same exact level height as shown in fig. 1,757 with the long cross-cut timber saw by nailing cleats on both sides in the manner illustrated in fig. 1,756.

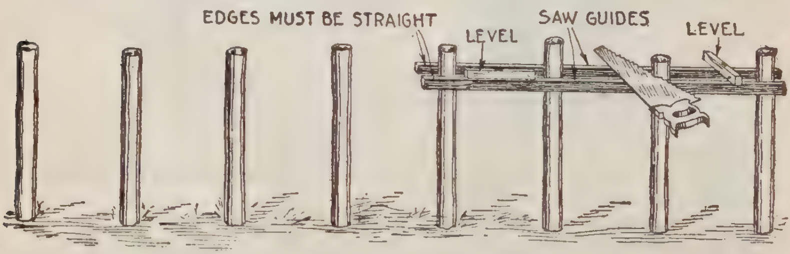


FIG. 1,758.—Method of sawing off posts square and in the same plane by aid of long cleats so that the tops of all will touch the sill. For a good job this work must be done with precision. The edges of the planks used for cleats must be straight and in placing them in position they should be carefully leveled lengthwise and crosswise as indicated by the levels.

Where these are shown set level, some only use one cleat, but two are better on thick posts as they give steadier and more accurate cut.

A better method, especially where the posts are set close together is to use long planks for cleats, each setting taking several posts as in fig. 1,758.

Finally the usual care, skill and patience must be employed and it is essential that the ground be dry, firm and free from swamp or quicksand.

Earth Excavation.—In every building specification made by a competent architect or engineer the details of the excavation

FIG. 1,759.—Contractor's pick. It is useful in loosening up hard and rocky earth. The head weighs from 7 to 10 pounds.

form an important part. There is hardly a class of building construction into which excavation of earth or rock does not enter to some extent.

The following data on earth excavation will be found useful:

One excavator using pick and spade, will keep busy two shovellers and

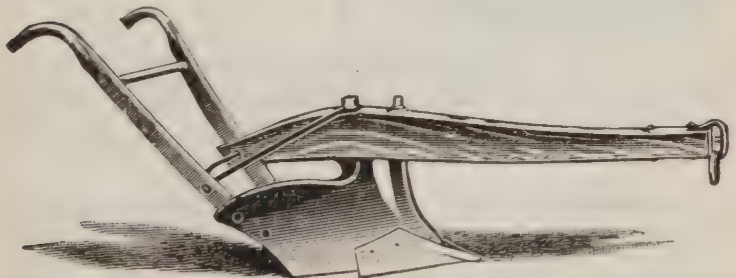
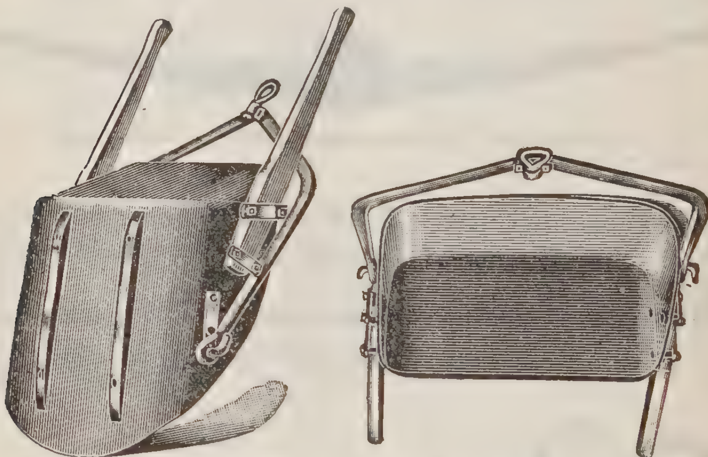


FIG. 1,760.—Contractor's plough used in trenching or grading in common ground, and even gravel and road materials, as it is claimed. The material loosened by the plough is removed by the scraper, two patterns of which are shown in figs. 1,761 and 1,762. In each case the plough and scraper are drawn by a pair of horses.

two barrow wheelers in compact earth, but only one of each on ordinary clay.

A shoveller will throw each shovel full of earth six to ten feet horizontally, or four to five feet vertically.

In an eight-hour day a good excavator will dig and throw into a barrow six to eight cubic yards of common ground, about five cubic yards of firm clay or compact gravel, or from two and one-half to four cubic yards of hard ground where the pick has to be employed. One excavator to each six feet of face of cutting is as close as is desirable.



FIGS. 1,761 and 1,762.—Two forms of scraper. These are like steel scoops, shovels or spoons, used for moving loosened earth or other material; a pair of horses are harnessed to the bail or cross piece by means of whiffletrees, and the scraper is then drawn over the ground, scraping up the surface like a spoon. The tool has a capacity ranging from three to seven cubic feet, and is guided by the driver, who dumps the contents at the required spot by manipulation of the handles and steering the horses so as to tip the scraper.

Wheelbarrows holding $1/_{10}$ cubic yard, are the most economical means of transport where the distance does not exceed 100 yards. Barrow runs should be provided, as they increase the capacity of the wheelers by at least 50 per cent. These consist of 12″ × 3″ planks, mounted on box horses where it is desired to give an inclination. The gradient should not be steeper than one in twelve, unless assisting gear, such as hauling ropes, be provided. Efforts should be made to keep the slope down to one in thirty.

A barrow run is reckoned as about twenty-five yards, each foot of rise being estimated as equal to two or three yards extra run.

Tip carts drawn by one horse are much used in transporting earth, but with them as with barrows it is more economical to provide good temporary ways, as the hauling power will be doubled thereby. Assuming good ways, a cart can hold $\frac{3}{4}$ cubic yard of earth, or say 1 ton.

In dealing with the removal of earth from long and narrow trenches, as in the case of foundations, most of the foregoing methods cannot be used.

A rectangular bucket, narrow in comparison with its length, as fig. 1,761 is designed for this special service, and is intended to be worked by a crane or hoisting engine.

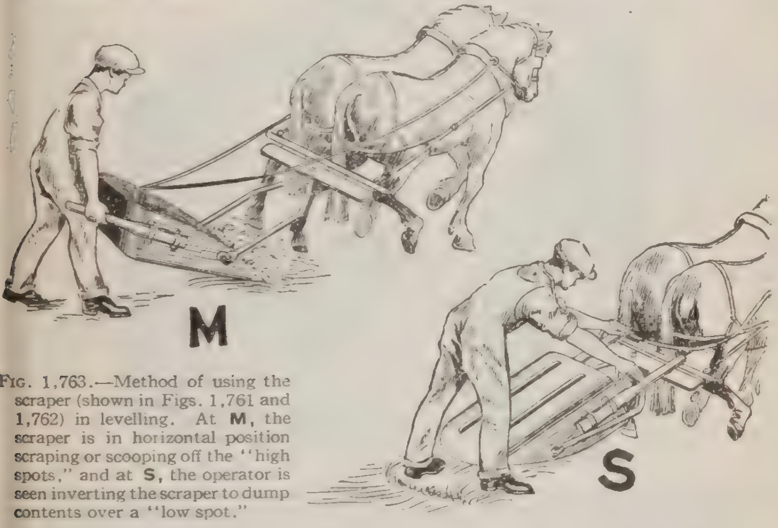


FIG. 1,763.—Method of using the scraper (shown in Figs. 1,761 and 1,762) in levelling. At **M**, the scraper is in horizontal position scraping or scooping off the "high spots," and at **S**, the operator is seen inverting the scraper to dump contents over a "low spot."

A method, modified from a mine prospector's device, is as follows: A trestle is erected astride the trench, having a runway *rising* slightly to the dump. A four wheeled carriage rests on this runway, and is locked in position by a catch over the trench; from this carriage depends the pulley for the bucket rope. A horse travelling horizontally pulls the bucket vertically; as soon as it is fully hoisted it disengages the carriage, and the horse pulls carriage and all to the dump. As soon as the bucket or skip is emptied, and the horse starts to return, the carriage runs back along the

runway by its own weight, and becoming automatically locked again, the bucket descends into the trench once more.

If a portable railway can be used, it is also advantageous in working on a slope, to have the team of horses travel on the level, pulling at a rope led around pulleys and fairleads.

Shoring.—The term *shore*, in carpentry, means an upright or slanting strut or brace, the upper end of which presses against the object supported. Shoring or the insertion of such braces or struts is frequently resorted to in excavating foundations;

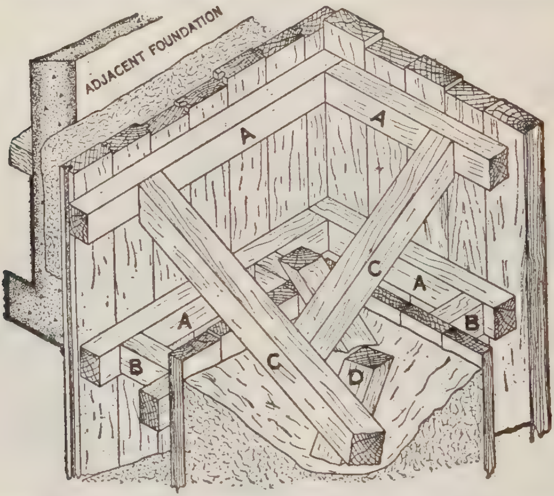
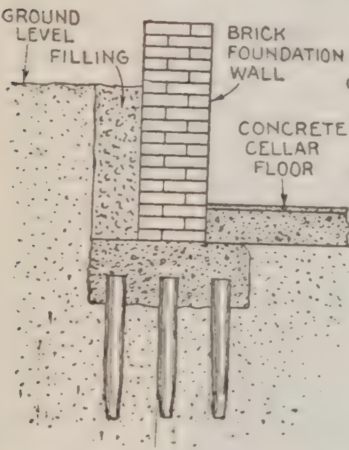


FIG. 1,764.—Detail of shoring showing method of construction when an excavation is to extend below an adjacent foundation or one near enough that might be endangered by it. When the excavation is made as deep as it is safe to, planks of a suitable size are sharpened on the bottom end and driven down behind walls AAAA; when wanted very tight they are tongued and grooved. Braces CC, are spiked to wales and to post anchors D, that are driven securely into the earth. When an inside row of planking is used to form trench, braces B, hold them a uniform distance apart. They are removed as the foundation rises.

this means placing timber struts obliquely against the walls of a building to support it, should it be in danger of falling, or whenever alterations are being made to its base. Naturally, if an excavation be carried close to the walls of an existing structure.

the pressure will tend to force the footings sidewise, and a collapse is threatened.

Rectangular holes are cut in the upper part of the wall to be supported, in which are placed timber *needles* usually six inches square and a foot long, projecting seven or eight inches. On these needles is placed vertically a stout plank, its length depending upon the height of the building. Shores are arranged in tiers of three, abutting on one end upon a footing block of wood, and at the other upon the upper, middle and lower



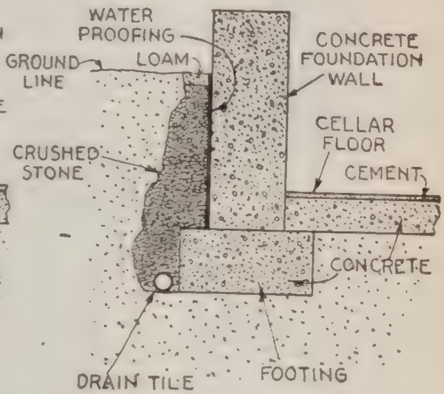


FIG. 1,765.—Foundation construction showing footing of piling embedded in concrete cap, and brick foundation wall, the cellar being provided with a concrete floor.

FIG. 1,766.—Foundation construction of all concrete showing method of water proofing with crushed stone and drain pipe.

needles through each plank. A customary size for these struts or shores is 12″ × 6″.

A cleat is usually nailed to the plank on the upper side of each needle to reinforce it, and one inch planks are nailed to the sides of each tier of shores to hold them together.

In deep excavations an important point is to have proper shoring; have the planking and timbers so placed that it will prevent a cave in. Fig. 1,767 shows ordinary shoring consisting of a framework and planks.

Underpinning.—This comprises a solid structure introduced temporarily or otherwise beneath the foundations of an existing

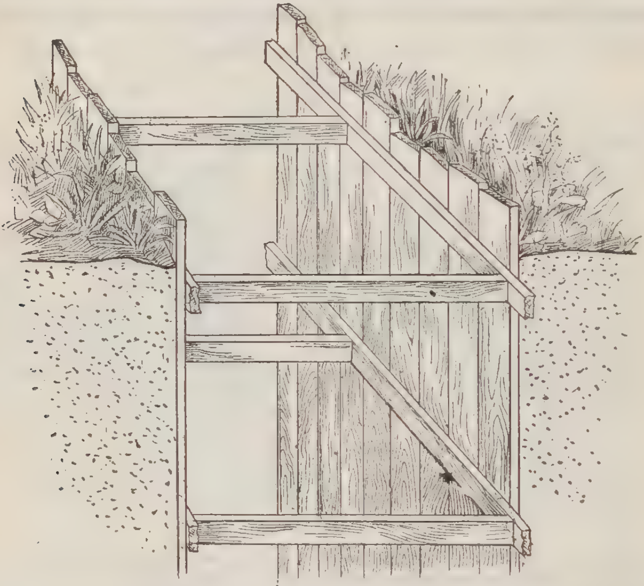


FIG. 1,767.—Ordinary shoring. ***In construction,*** put planks behind the frame and drive them down with a wooden beetle as far as possible. Always dig on the outside line of the hole first, say about two feet deeper than the center; this gives a chance to lower the frame and planks and makes the work easier. As in many cases where the soil is very soft and water appears at no great depth, have a place kept lower at all times to put a pump in or bale out.

building to support them in case of alteration or excavation beneath the footings.

A favorite method of underpinning is to build piers in pairs, one each side

of the threatened wall, to the desired height from solid ground. The wall is pierced for rectangular wooden beams, termed "needles," which rest with one end on each pier of a pair. Wedges being driven in under the needles, the weight of the wall is transferred from the footings to the piers.

Footings.—The term *footing* means *the lower and expanded portion of a foundation which rests on the excavated surface.* It is made wider than the foundation wall so as to reduce the pressure (per unit area of surface) to be supported by the excavated sur-

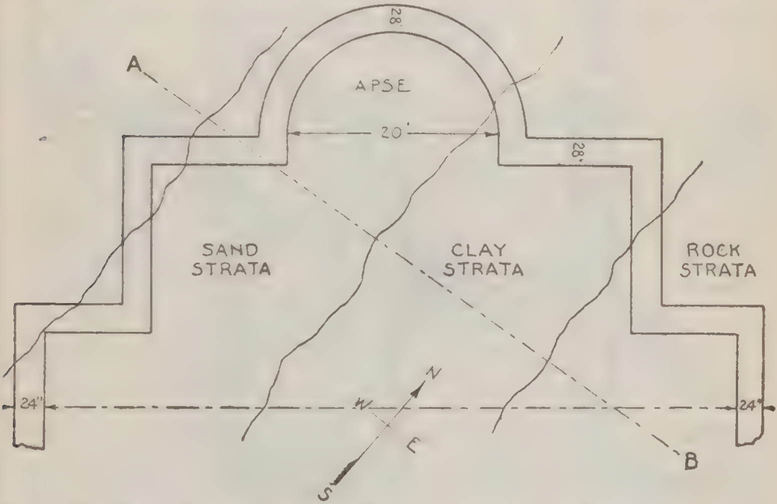


FIG. 1,768.—Foundation plan of part of a church showing various materials, sometimes found in excavating.

face and thus reduce or prevent settling. The extent of this widening of the footing will depend upon the nature of the excavation or surface upon which the footing rests and the weight coming on the footing.

To illustrate this, assume that fig. 1,768 represents the plan of a proposed building and that the materials of the earth under the footings are composed

of different strata, as rock, clay and uncertain sand, a condition not unusual in modern work, and that these materials are located as represented by the wavy lines.

The capacities of the materials being different, it must be understood that they must be differently treated, so as to be, when treated, all of equal capacity. For instance, rock is a stable material by itself capable of sustaining a weight of 200 tons to the square foot and fully fit. The other materials on which the foundation is to rest are compressible and unfit, so that they must be treated artificially to bring them up to the standard of the rock.

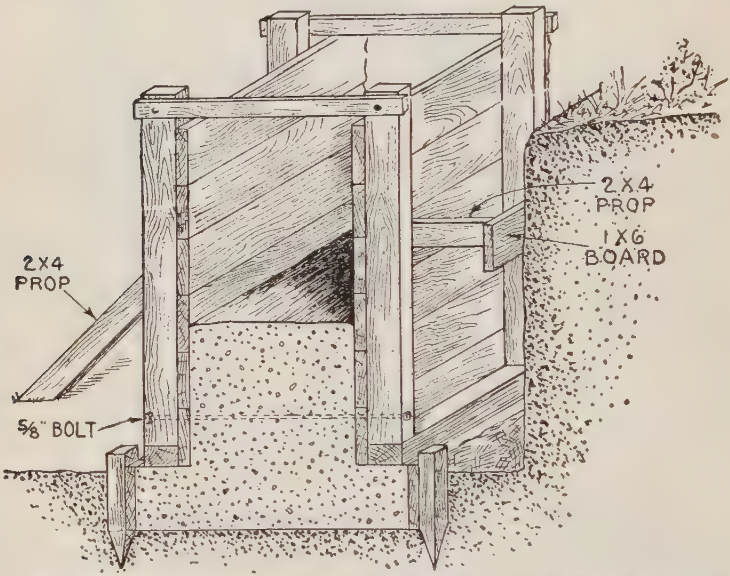


Fig. 1,769.—Form for concrete foundation wall and footing such forms should be made of semiseasoned wood as when thoroughly seasoned, the wood will warp badly when the wet concrete is placed. Spruce, Norway pine, etc., are better woods to use than hard or Georgia pine. For ordinary foundation work 1-inch boards may be used. The studs may be assisted materially in holding the forms in position, by wires placed on studs. And by props placed against the dirt wall of the excavation. ***In filling,*** use a wet mix; lay a 4-inch layer and then spade or work it well into place. The smoothness of the resulting faces is increased by an additional spading of the mixture away from the form. A good spading tool is made by straightening out an ordinary garden hoe. Forms should be allowed to remain until the concrete will resist indentation with the thumb upon ordinary walls.

In preparing such a bottom, begin at the sand portion, and make it fit by excavating to the specified depth or even past that to a good solid strata deep enough and dense enough to carry the weight superimposed; but if there be a possibility of the sand layer resting on the sloping top surface of the dipping rock, then he must dig down to the rock and level it off for a bearing. Should, however, the sand be retained within a hollow spot or basin in the rock, then the sand will be safe enough to build on, but this must be made sure of by test holes.

The same directions apply to the clay stratum, which varies sometimes

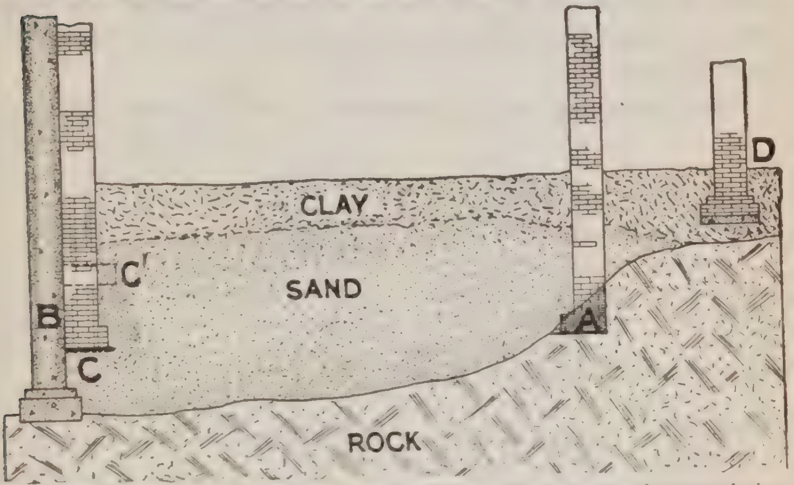


FIG. 1,770.—Section of foundation, showing at A, a rock condition below a sand stratum sloping at a point where a foundation base must be placed and how it is leveled for it to avert any possible danger of its creating a pressure against the resisting sand by which it might yield upward where not under compression other than its own weight, thus allowing base to slip and cause disaster. If it is to be placed against another wall as at B, it will be safe to lay the base at any depth below frost in the sand as at CC′. The sand cannot yield or be displaced unless voids are created. At D, the rock bed is quite level and the clay rests upon it, here the base of foundation may start, even without going to rock bottom and be perfectly safe.

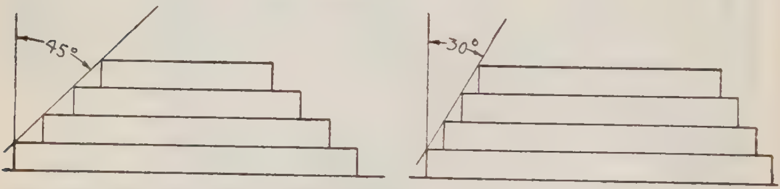
more than sand, especially when there has been a deposit of water, showing a blue spongy material in the composition, which constitutes a compressible turf; in fact, clay varies more than sand, and consequently it must be more closely scanned to ascertain its nature and capacity.

Concerning the material for the footing courses on bottoms of this assorted nature, concrete is considered the most reliable.

Sometimes the excavated surface is rendered fit for supporting the foundation by driving down a number of piles, the foundation being in fact carried by these piles. Many fixed standards are given for footings and foundations.

The New York Building Code requires all footings to extend in ordinary concrete or bottom stone six inches outside the face of all walls or piers, or the spread of the footing to be 12 inches wider than the wall or pier which it will carry, and not less than 8 or 12 inches deep, which is in accordance with the rule followed by architects.

Brick footings on rock or concrete may be used if properly spread and



FIGS. 1,771 and 1,772.—45° and 60° footings.

bonded, but a given proportion set to a recognized and fixed angle will be necessary.

Fig. 1,771 shows a stepped-up footing of brickwork, with the steppings set to an angle of 45 degrees, which is easily obtained by setting back two inches, on the square of the thickness of each brick, until the thickness of the pier or wall is reached. Similarly in fig. 1,772 the foundation is set back or splayed to an angle of 60 degrees (with the horizontal), with one inch steppings on each course.

Some prescribed angle should always be adhered to, calculated, of course, according to weight of wall or superstructure, and the earth or rock upon which it starts. Also a very important matter is to preserve the bonds always with a two-inch overlap.

Every pier or brick buttress must have its foundation footing placed at right angles to the axis or center line of its axis, be it plumb, racking, or battered, so that the thrust on the base shall be directly on the axis line.

Finally, as a general rule, all foundations and footings should never be less than one-third wider than the wall above.

Filling.—After foundation walls have been completed, the earth previously excavated must be filled in against the outer sides up to the level of the ground.

Many new walls have been sprung, sometimes so badly as to

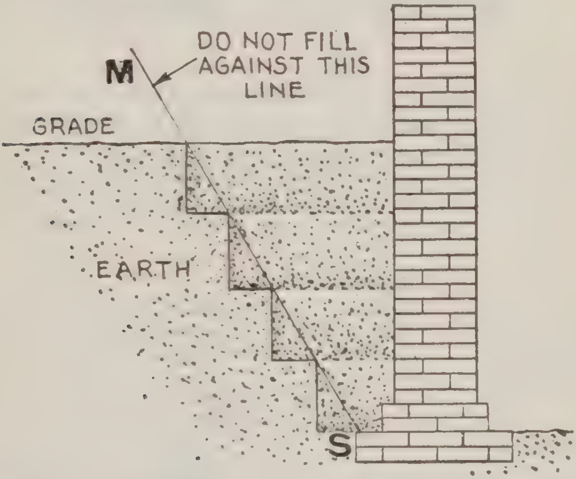


FIG. 1,773.—Correct method of filling against wall. Evidently the fill is partly supported by the series of steps rather than wedged against the wall when the side of the excavation slopes outward as indicated by the line **MS**.

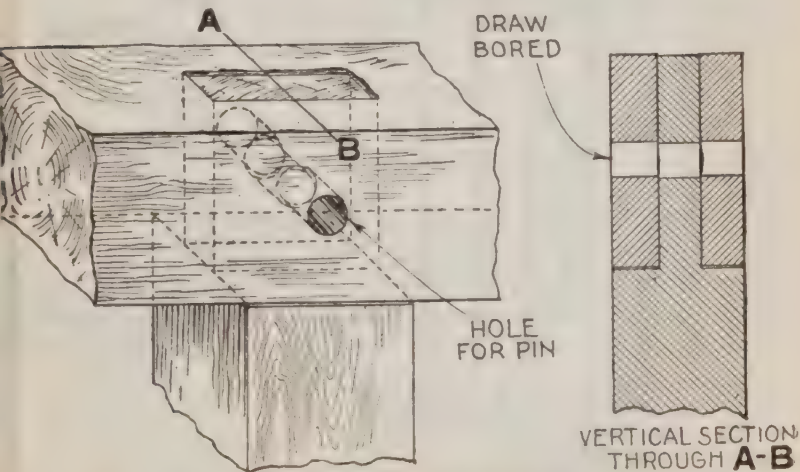
have to be rebuilt, on account of improper method of filling. Sometimes heavy walls are thrown down by filling in with earth between the wall and the inclined bank of the excavation, causing a sliding pressure against the wall as the fill and weight increases. Sometimes the slide is accelerated with much water settling through it before finally settled, which takes much longer than the seasoning of the mortar in wall.

The simple remedy is to level the bottom and square the sides in step courses as the fill is made, as shown in fig. 1,773; this prevents the wedging action which would be present were the side of the excavation sloping as indicated by the line MS.

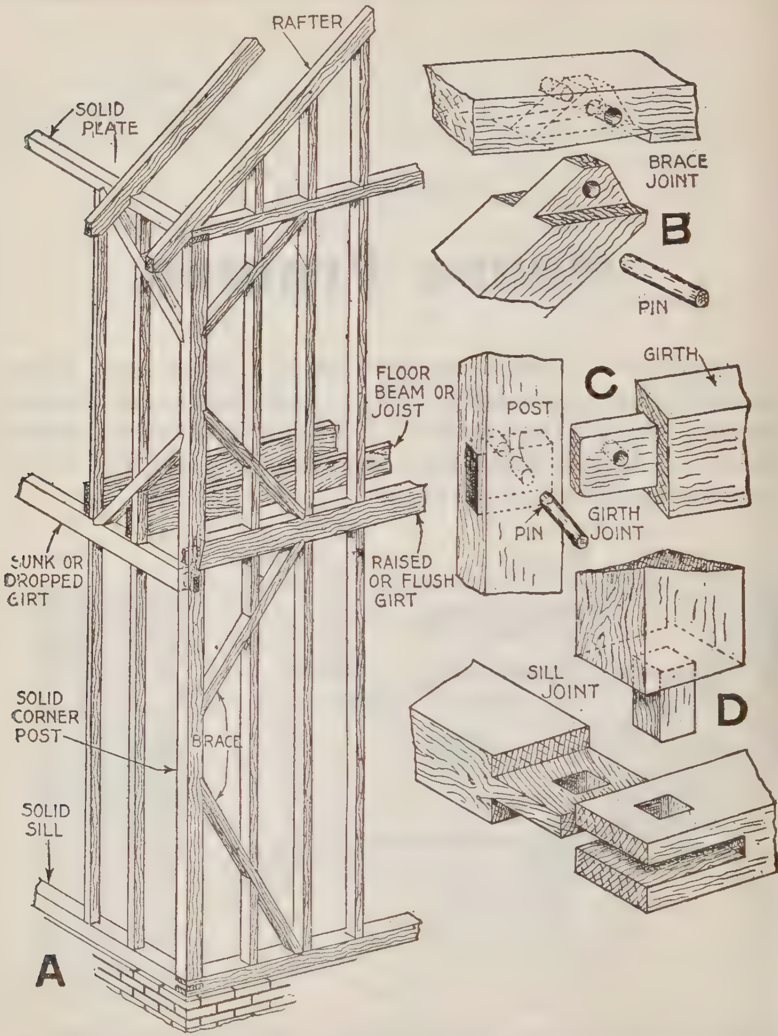
CHAPTER 37

House Frames

The frame of a house comprises the sills, corner posts, braces, studding, girts or ledgers, girders, floor beams, cap or plate, rafters, etc.; it is the network of timbers to which the outside covering, floors and partition walls are attached. The various types of frame are classed as:



FIGS. 1.774 and 1.775.—***Basis of the full frame:*** the mortise and tenon joint draw bored. Imagine the expense today of fastening together the various members of a house frame with these joints, and the cost of the massive timbers.



FIGS. 1,776 to 1,779.—Full frame and details of the joints **A**, corner of frame showing the various members; **B**, brace joint; **C**, girth joint; **D**, sill joint.

1. Full.
2. Balloon.
3. Combination, or half.
4. Barn { heavy timber / plank

Full Frame.—In the early days when lumber and labor were cheap this type of frame was universally used. It consists of heavy and solid timbers fastened together with mortise and tenon joints secured by pins. The frame is in fact put together without the use of any nails except for rafters and in spiking the floor beams and small pieces in place.

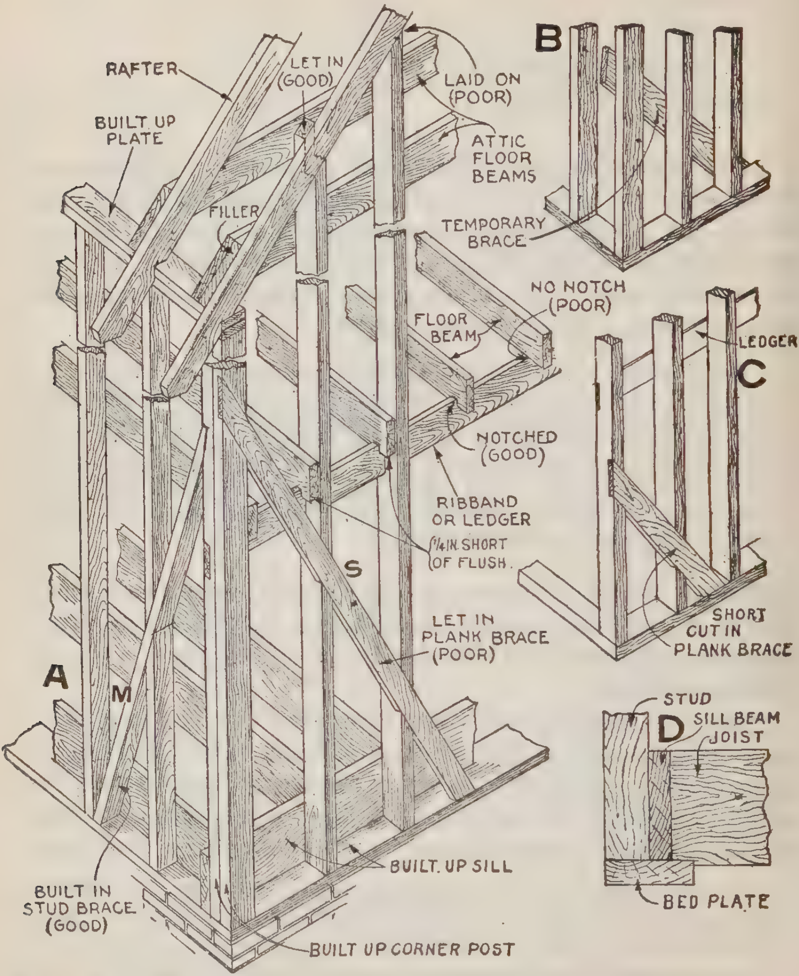
The excessive amount of labor required to make all these joints and cost of the heavy timbers required render this type of frame so expensive today that it is rarely used, inferior or makeshift framework of the balloon type, later described, having come into general use to reduce the cost. The mortise and tenon joint secured by a pin as just mentioned, and as shown in figs. 1,774 and 1,775, is the basis of the full frame and the characteristic features of this frame are shown in figs. 1,776 to 1,779. Note the elaborate mortise and tenon draw bored joints.

Balloon Frame.—This is a cheap and as usually put together a more or less objectionable construction. A well built balloon frame is satisfactory for a moderate sized house, but how often is one well built?

Since the balloon frame is a type which invites poor work and a certain class of builders cannot resist such a temptation, it has a bad reputation. In many cities a balloon frame is not accepted within the fire limits, though a combination frame usually will be accepted wherever a wooden building is allowed.

A distinguishing feature of the balloon frame is that it is built of light (in fact *usually too light*) timbers which are fastened by spiking or nailing, there being no mortise and tenon joints.

Built up sills of light construction are used, the studs extending from the sill to the plate if pieces of the right length can be obtained, otherwise they are fish jointed.



FIGS. 1,780 to 1,783.—Balloon frame and details of construction. **A**, corner of frame showing the various members. M, is a substantial built-in stud brace, and S, a cheap let-in plank brace. **B**, temporary brace; **C**, short let-in plank brace; **D**, detail of built-up sill.

Ribbands or ledger boards are cut into the studs to carry the floor beams on the second floor. The braces may be temporary or permanent.

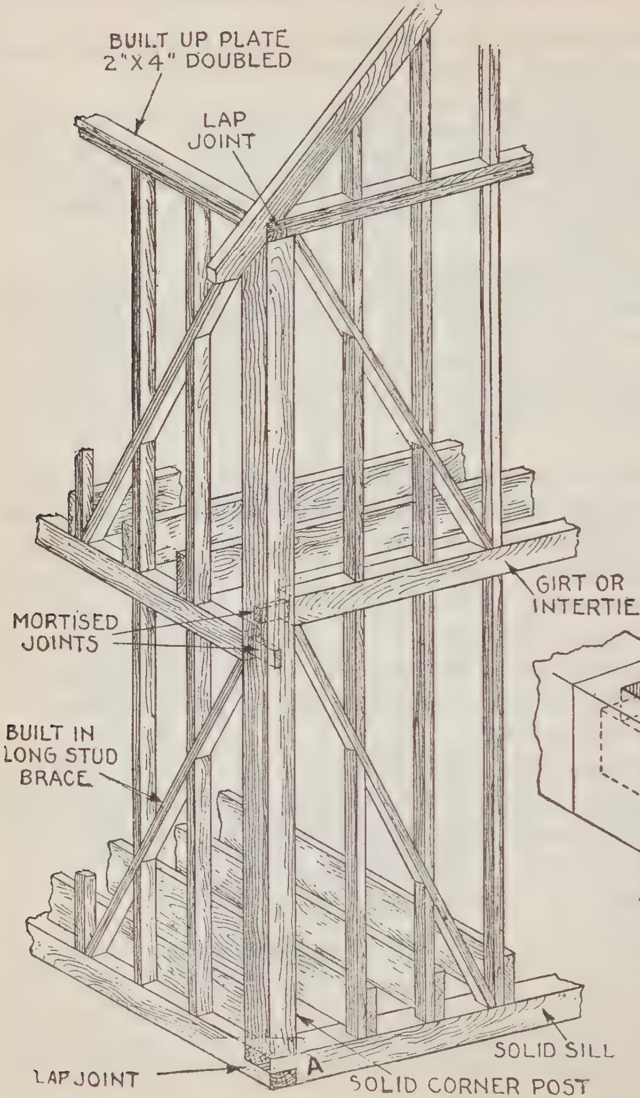
An unscrupulous builder will reinforce the framework with temporary braces or diagonal pieces consisting of light planks nailed on at the corners and remove them as the siding is put on, depending on the latter for stiffness. These temporary braces (made of 1-inch stock) could easily be made permanent by being let into the studs so as to be flush with the outside. A better method is to use 2 × 4 studding.

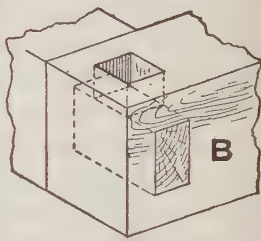
It is a bad characteristic of balloon construction to use the lightest timbers. The braces usually extend from the second or third stud on the sill to about two or three feet from the plate on the corner post, though an unscrupulous builder will not extend them above the second floor. A balloon frame is a fire trap unless properly *bridged* so that there cannot be any air circulation between the walls and siding. The general features of balloon framing are shown in figs. 1,780 to 1,783.

Comparison of Full and Balloon Frames.—In early days when people were content to live natural lives, and before the ruthless destruction of forests had reached its present stage, houses were built as they should be—substantial, well put together, and lasting. Conditions of today, however, preclude such construction. Houses are now usually built with a total disregard for lasting qualities and this is not always the fault of the builder, but of the purchaser who will not stand the expense of first class construction.

To those contemplating building a house the best advice that can be given is to keep the cost down by reducing the size of the proposed house rather than resorting to cheap makeshift construction. A very good comparison of the extremes of former and present practice is given by Radford as follows:

"Some fifty or fifty-five years ago when lumber was more plentiful, it was the common practice to build frame houses, great and small, with solid timbers. The sills, plates and corner posts were often hewn from the round timber with axe and adz, often taking months in preparing these for the 'new house.' In fact, it was quite the custom to commence the year before to get out the timbers, preparatory for the day of 'house raising.' After





FIGS. 1,784 and 1,785.—Combination or half frame, being a compromise between the super-substantial full frame and the makeshift balloon frame. Note

the timbers were hewn to the desired size, then came the work of laying out the mortise and tenons for joining the different parts together. No nails or spikes being used for this work.

"The corner posts were usually made out of timbers six or eight inches square with the inner corner hewn out to receive the lath and plaster. Think of doing that kind of work nowadays. This carries us back to the time of the building of our old home, now more than fifty-five years ago; though only a lad we remember the time the trees were being felled in the forest and, after a long wait for the timbers to be squared, they were hauled to the building site, and, after a time for them to season, the carpenters came and, as though but yesterday, we see them under the old apple trees astride the timbers with auger, chisel and mallet working away from morn till night.

"It was just so with all of the work connected with the building. The mill work was gotten out by hand, even to the sash and doors. How well they built their works remains as a silent witness; suffice it is to say the latter day workmen could gain some good pointers in construction from these old timers. Neither short hours, long hours, strikes nor lockouts worried them. Those were days of toil, days of contentment and peace. How different it is now!

"When the new house is decided upon, within sixty or ninety days it is ready to move into. The work is divided up into different classes and done by different workmen. The solid timbers are no longer used for the framework.

"In its stead the sills and other timbers are built up with joists and studding commonly known as balloon framing, and everything is rushed from start to finish, and in the hurry many things that should be done are overlooked, to the detriment of the house.

"Some of these things may require but little or no extra expense, if attended to at the proper time, but if neglected prove a serious detriment to the building."

Combination or Half Frame.—As a compromise between the extremes of old and present practice the combination frame gives a satisfactory construction at moderate cost. It makes

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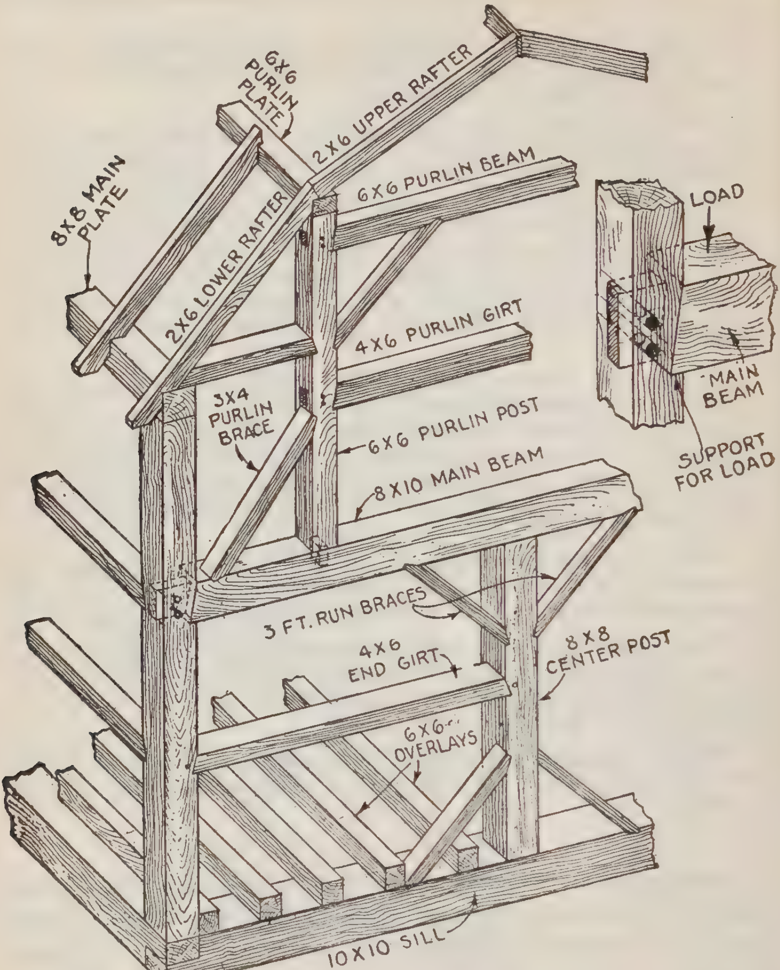
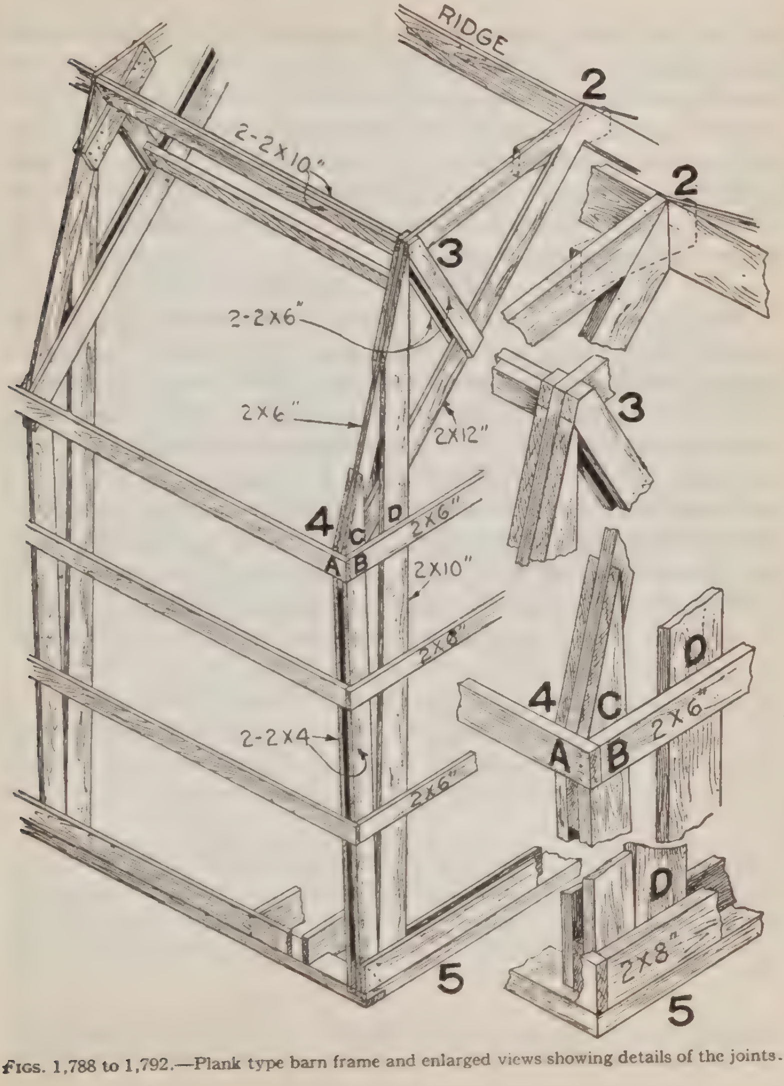
FIGS. 1,784 and 1,785.—*Continued*.

balloon type long braces, built-up plate. The braces may be mortised and tenoned or nailed. In the best frames of the type the studs are mortised and tenoned at the top and nailed at the bottom; ordinarily they are nailed at both ends. The sill joint may be lap, as at **A**, or mortised as at B, with short mortise for the post tenon as shown.



FIGS. 1,786 and 1,787.—Heavy timber barn frame, showing ordinary sizes of timbers for a 38 ×64 barn with 16-foot main posts, gambrel roof and detail of loaded joints. An important point in this kind of construction is that no timbers supporting a heavy load, as beams, cross sills, etc., should be allowed to rest on their tenons alone, but all should have a shoulder or bearing across the whole end of the timber as shown in fig. 1,787.



FIGS. 1,788 to 1,792.—Plank type barn frame and enlarged views showing details of the joints.

less use of heavy timbers and expensive mortise and tenon joints and more use of planks and nails, that is, the combination frame combines the desirable features of both the full and balloon frames, rejecting the unnecessary refinements of the full frame and the objectionable makeshift construction found in the balloon frame. Fig. 1,784 shows how some of the details of both types of frame are combined to form a desirable method of construction at moderate cost.

Barn Frames.—Of the two general types of barn frames, the heavy timber frame in which all the members consists of heavy squared timbers with mortise and tenon draw bored joints seem to be a survival of the sturdy construction of the early days before timber became partially extinct and was all hewed out by hand. The later type known as the plank frame is claimed by many to mark a decided improvement over the other as being more easily erected, equally substantial and much cheaper, especially where large timber is not easily secured. Figs. 1,786 and 1,787 show the general features of a heavy timber frame for a large barn and figs. 1,788 to 1,792, a plank frame.

CHAPTER 38

Girders and Sills

The preceding chapter gives a general idea of the several classes of frames. The various details of these frames vary largely, there being in general one right way and many wrong ways of constructing each part, and in this connection, purchasers, or those contemplating having a house built should be acquainted not only with the right way but also with the objectionable methods employed by some architects and contractors so as to reject the plans or work unless it be up to approved practice.

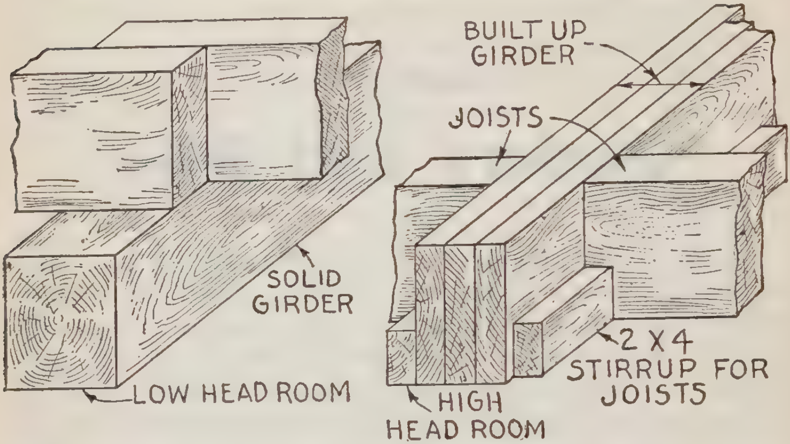
It is poor economy to specify cheap and inferior construction as houses so built are never satisfactory. In this and following chapters the various members of the frame, such as girders, sills, corner posts, studding, etc., are considered in detail, showing the numerous ways in which each part is treated.

Girders.—By definition a *girder* is *a principal beam extending from wall to wall of a building affording support for the joists or floor beams where the distance is too great for a single span.* Girders may be either solid or built up as shown in figs. 1,793 and 1,794.

The solid girder is easier to frame than the built up type, but gives less head room than the built-up type as can be seen from the illustrations.

Where extra strength is necessary and it is desired to save head room, a flitch plate girder as shown in fig. 1,795 is used.

An objectionable method of construction is shown in fig. 1,796. Here it



FIGS. 1,793 and 1,794.—Solid and built up girders. An ordinary size of built up girder is made of three 2 × 10s with a 2 × 4 attached to each side on which the joists rest, as shown.

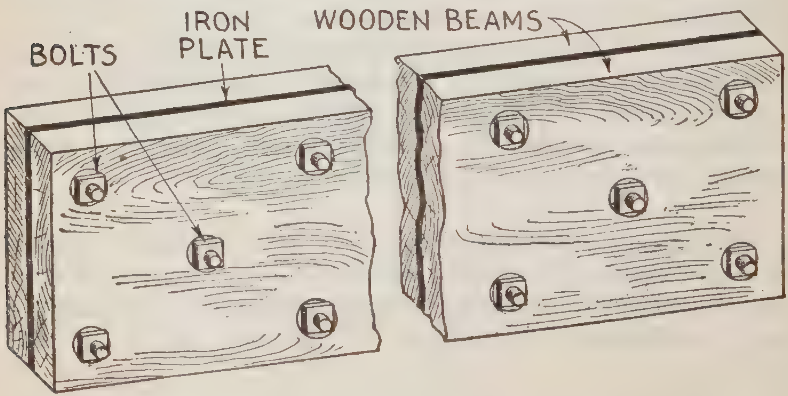


FIG. 1,795.—Flitch plate girder. *It consists of* an iron plate (called a *flitch* plate) bolted between two floor joists. This construction may be regarded as a substitute for an I beam.

must be evident that the strength of the girder is considerably reduced by the wood removed for the mortised joints.

In laying out the girders they must be cut to such length that they will have not less than six inches bearing on the walls.

Placing Cellar Girders.—These will require to be lifted into the place on top of the piers and walls built for them in the

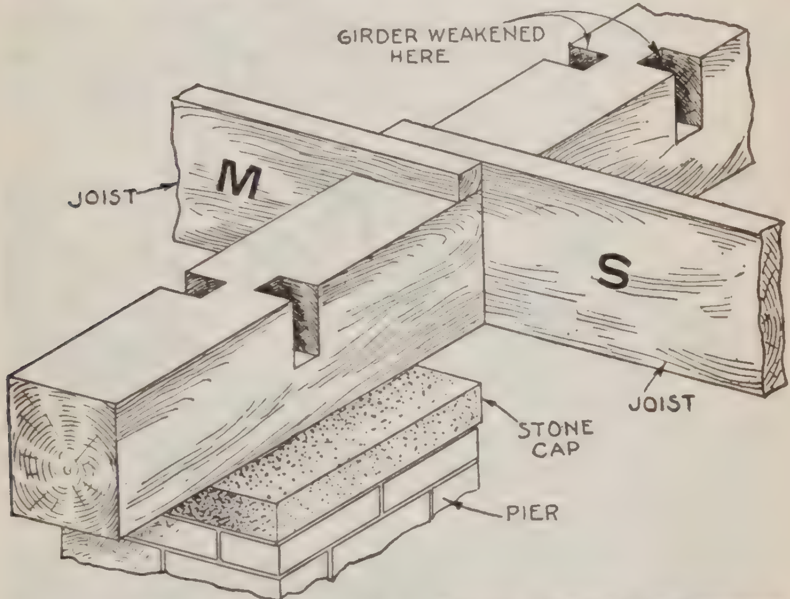
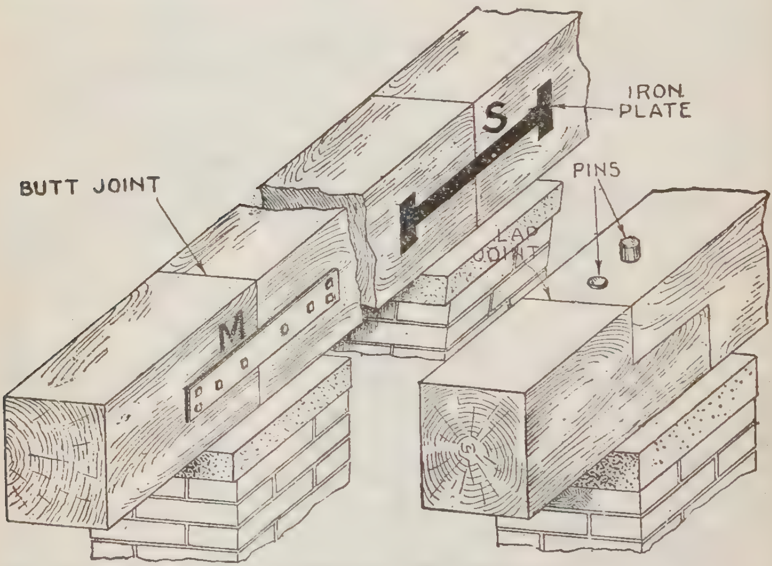


FIG. 1,796.—Solid girder with floor beams let in. Ordinarily a 6×8 yellow pine girder is used supported on a 12 × 12 brick pier with bluestone cap. The floor beams M, and S, are let into the girder to a depth of 4 inches. The top 2 inches of the 2 × 10 beams rest on top of girder, thus making girder flush with bottom of beams. The construction is objectionable not only on account of the unnecessary labor required to cut the numerous mortises for the floor beams, but especially because of the reduction in strength of the girder due to the wood removed in cutting the mortises.

cellar, and set perfectly level and straight from end to end. Some prefer to give their girders a slight crown of say 1 inch in

the entire length, and it is a wise plan, because the piers generally settle more than the outside walls. When there are posts instead of brick piers used to support the girder, the best method is to temporarily sustain the girder by uprights made of pieces of 2 × 4 joists resting on blocks on the ground below. When the superstructure is raised these can be knocked out after the per-



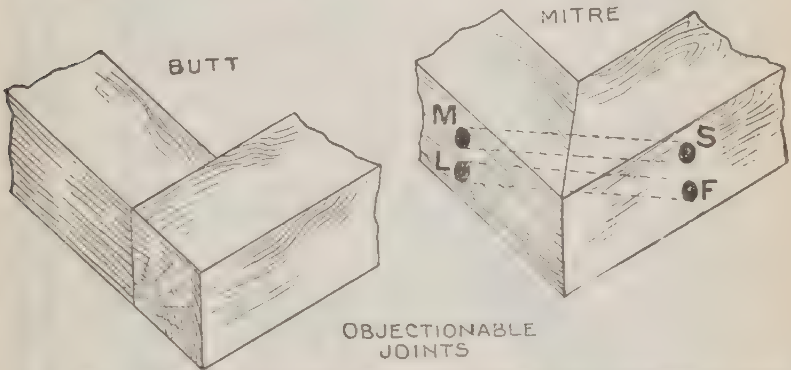
FIGS. 1,797 and 1,798.—Two forms of iron strap tie for fastening two girders at pier. At **M**, is shown a simple rectangular iron strap, one being nailed to the two beams on each side. **S**, shows the T, form or "strap anchor." The full retaining or "anchoring" power of the T, ends is obtained by letting these straps into the girders making them flush and their nailing. This gives a very strong joint where great resistance to tensile stresses is desirable, but ordinarily the labor of mortising the girder ends to let in the anchor straps is a waste of time.

manent posts are placed, resting their bottom ends on a broad, flat stone, to form a base or foundation footing.

If the supporting posts and piers be not placed or built until after the building is erected, then carpenters should exercise good judgment when jacking the girders up to place them under

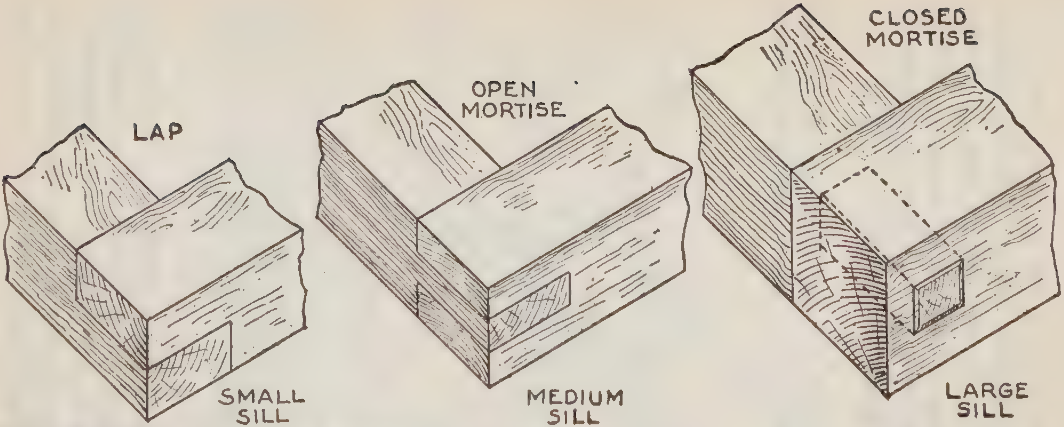
the girders and not raise them so much as to strain the building, and it is always desirable to obtain the crown mentioned before. The practice of temporarily shoring the girders, and not placing the permanent supports until after the superstructure is finished, is favored by good builders, and it is well for carpenters to know just how it should be done.

Sills.—A sill is *that part of the side walls of a house that rests horizontally upon the foundation*, to which it should be securely fastened.



FIGS. 1,799 and 1,800.—Objectionable methods of joining sills at corners. The square butt joint (fig. 1,799) is very objectionable as it depends upon the boarding and the finish to hold the sill together. No architect or carpenter who values his reputation will specify or construct such a joint. The mitre joint (fig. 1,800) although there is a chance to fasten with bolts MS, and LF, is not much better as the labor required to saw the mitre could be spent making a lap joint which would permit a locking mortise and tenon joint with the corner post (later explained).

There are numerous types of sills, and some of the creations that now go under the name of sill would not be recognized by an old time workman; in fact a stretch of the imagination would be necessary to associate some of these modern contrivances with the duty they are supposed to perform.



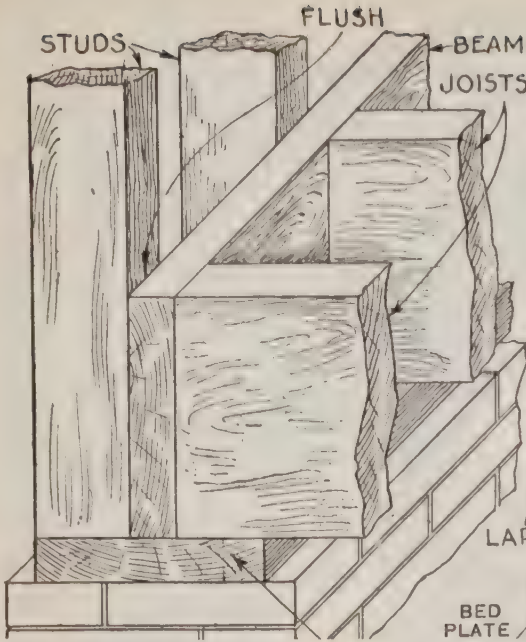
FIGS. 1,801 to 1,803.—Various joints for solid sills.

Sills may be divided into two general classes:

1. Solid.
2. Built up.

in other words real sills and substitutes for sills. The latter in many instances have become more or less a necessity owing to the scarcity and high cost of timber especially in the large sizes.

Figs. 1,799 to 1,803 show solid sills and the methods employed to join them at the corners, the butt and mitre joints shown in figs. 1,799 and 1,800 being very objectionable (especially the butt joint).



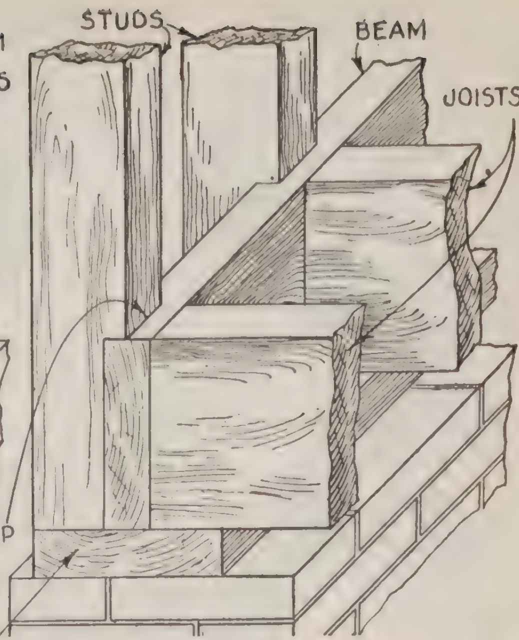
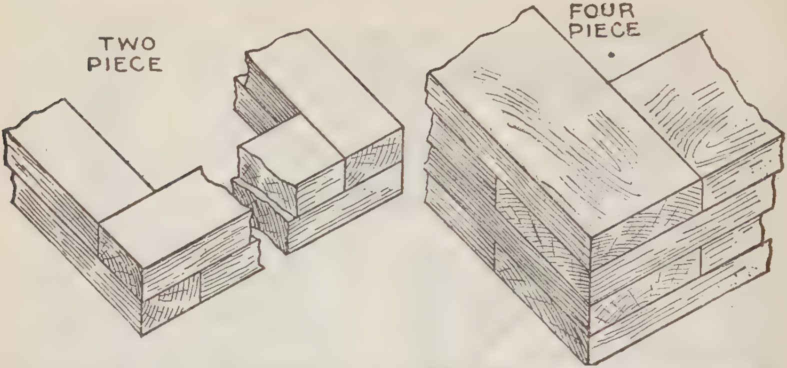


FIG. 1,804.—Built-up T sill with external flush studs. *It consists of* a horizontal member of *bed plate*, say 2×10, and an upright member or beam same size as the floor beam, 2 × 8, placed 4 ins. from the outer edge of bed plate to leave space for the studs on the outside as shown. This construction is simple, and gives full strength of the studding, also simplifies the laying of the flooring as there is no studding to cut around. An important point is that the sill is draught and rat proof.

FIG. 1,805.—Built-up T sill with external let-in studs. This is virtually the same construction as fig. 1,804, save that the studs are cut away at the lower end, giving a footing on the beam.



FIGS. 1,806 and 1,807.—Built-up solid sills consisting of two or more timbers two ins. thick thoroughly spiked together with the ends overlapping as shown. If the pieces be crooked or sprung they often may be straightened by nailing pieces together which are sprung in opposite directions.

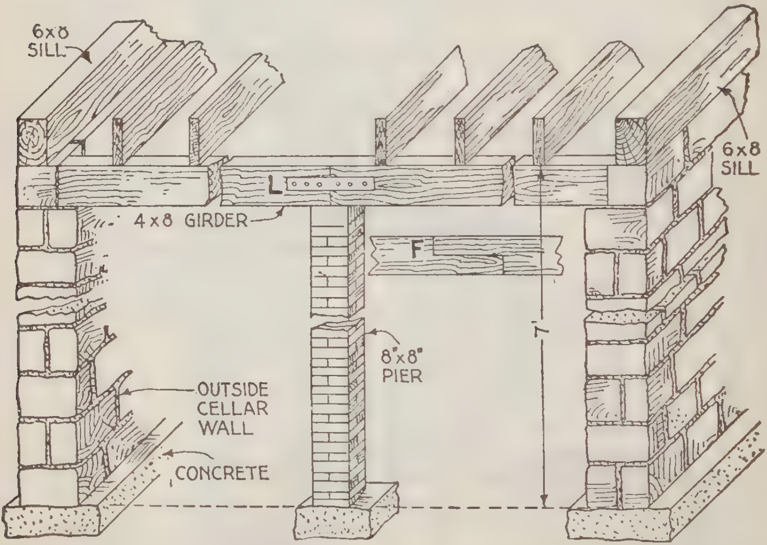
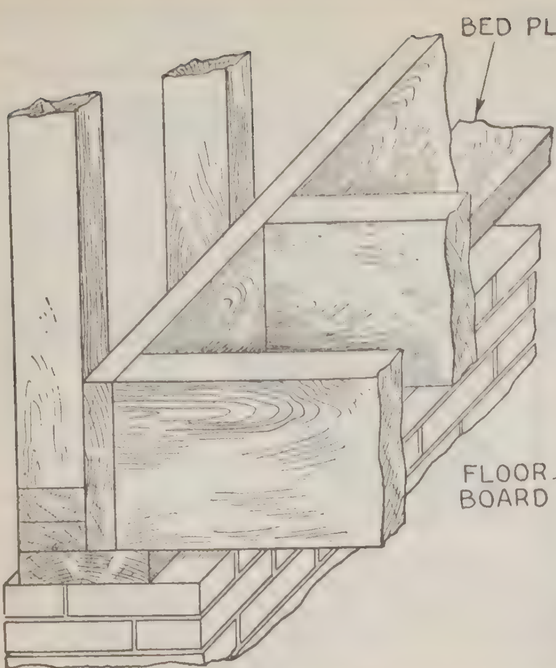


FIG. 1,808.—Cross section of cellar of small frame house showing foundation, pier, girders, sills and floor beams. Where the girder is made up of more than one piece, the lengths are usually butt jointed as shown at L, but sometimes a half lap joint is used as at F.



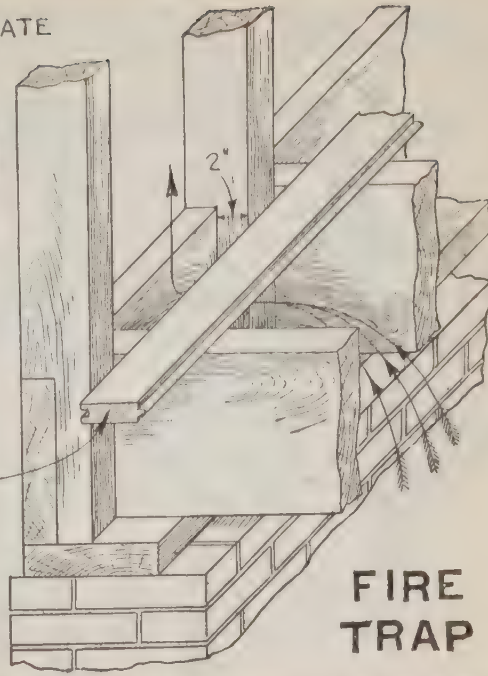


FIG. 1,809.—Built-up T sill with combination three-piece bed plate, and beam spaced for external studs. The bed plate is reinforced by two layers of studding laid along the outside edge and forming a stiff footing for the wall studs.

FIG. 1,810.—Built-up L sill with internal let-in studs. This construction is faulty in that the sapce between lath and siding is not shut off from the cellar, allowing access of rats and draughts, as indicated by arrow. *Such construction is a fire trap and should not be permitted.*

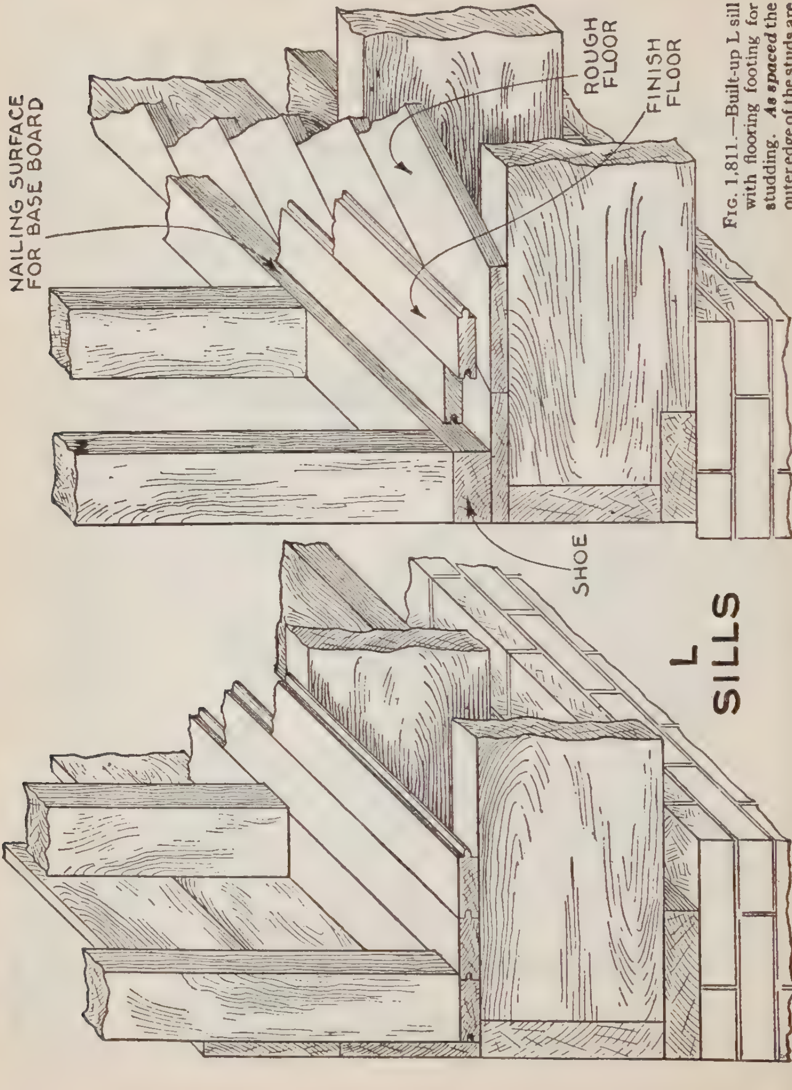
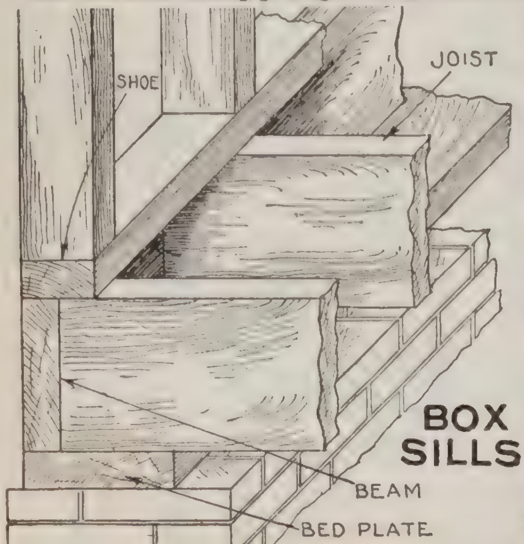


FIG. 1,811.—Built-up L sill with flooring footing for studding. *As spaced* the outer edge of the studs are

FIG. 1,811.—*Continued*.

flush with the outer floor plank edge which partly overlaps the sill beam, leaving space for the siding to come flush with the beam. Cheap and inferior construction.

FIG. 1,812.—Built-up L sill capped with diagonal rough flooring and flush studding as footing or *shoe* for the upright or wall studs. ***In construction,*** the diagonal floor is laid and the shoe put on this floor and spiked down to every joist. This shoe being the same width as the studding, gives a good nailing surface for the bottom edge of the base board after the lath and plaster are on.



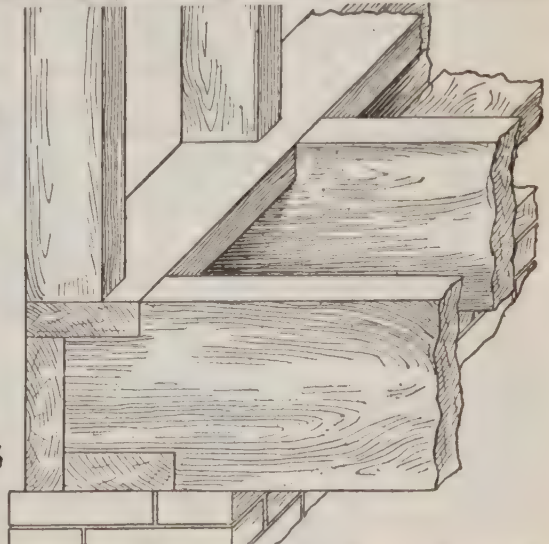
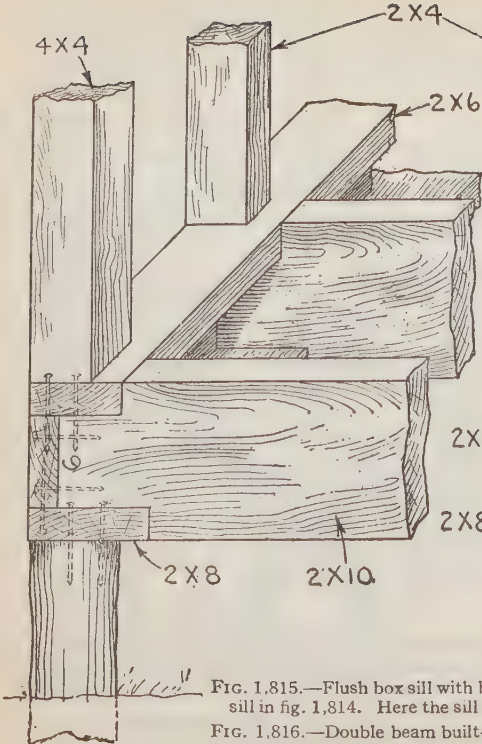


FIG. 1,813.—Plain box sill. ***It consists of*** three parts: bed plate, beam, and shoe. It is built so as to fit around the ends of the joists, no cutting being required.

FIG. 1,814.—Flush box sill with let-in joists. As shown, the ends of the joists are cut away at the upper and lower edges to fit in between the shoe and bed plate bringing these members flush with the joists.



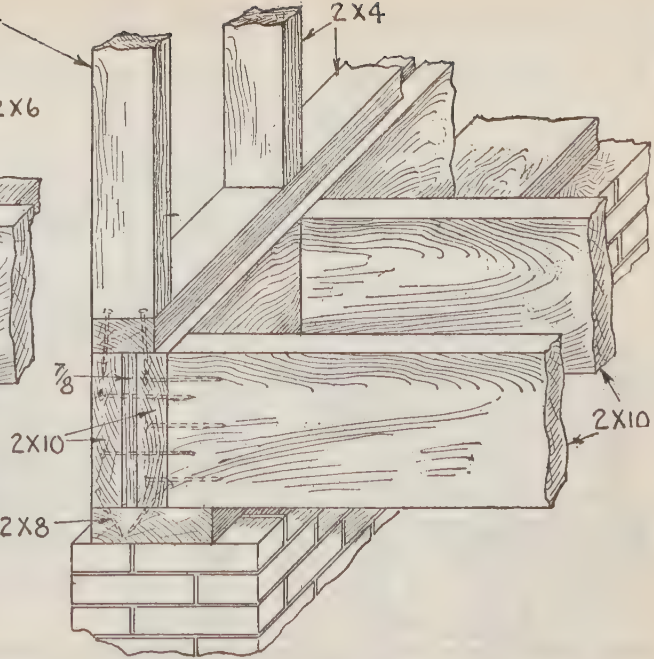


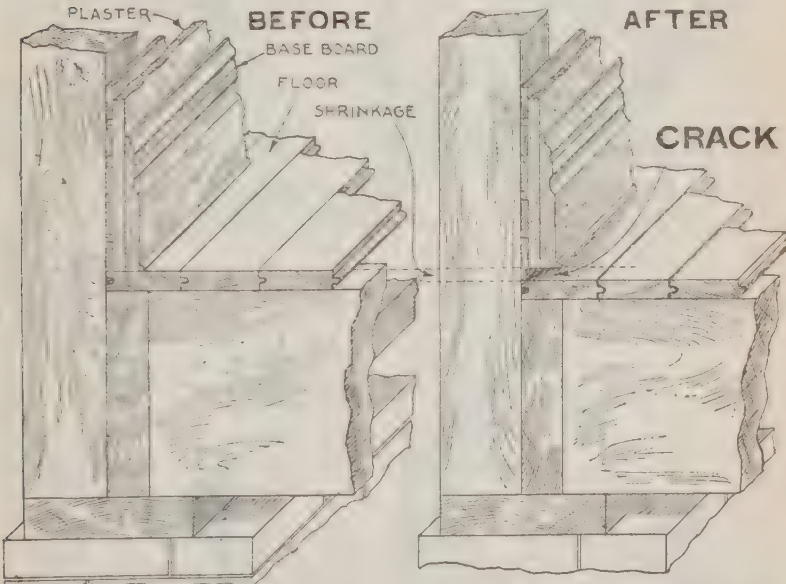
FIG. 1,815.—Flush box sill with bed plate and shoe lapped over edges of beam, otherwise similar to the sill in fig. 1,814. Here the sill is supported on posts.

FIG. 1,816.—Double beam built-up sill consisting of bed plate, two beams with spacers, and shoe. The extra beam gives added strength, spacers being inserted to separate the beams and give an overlap inside of the shoe, which serves as a good nailing surface for a diagonal rough floor.

Figs. 1,801 to 1,803 show desirable joints for sills of various sizes.

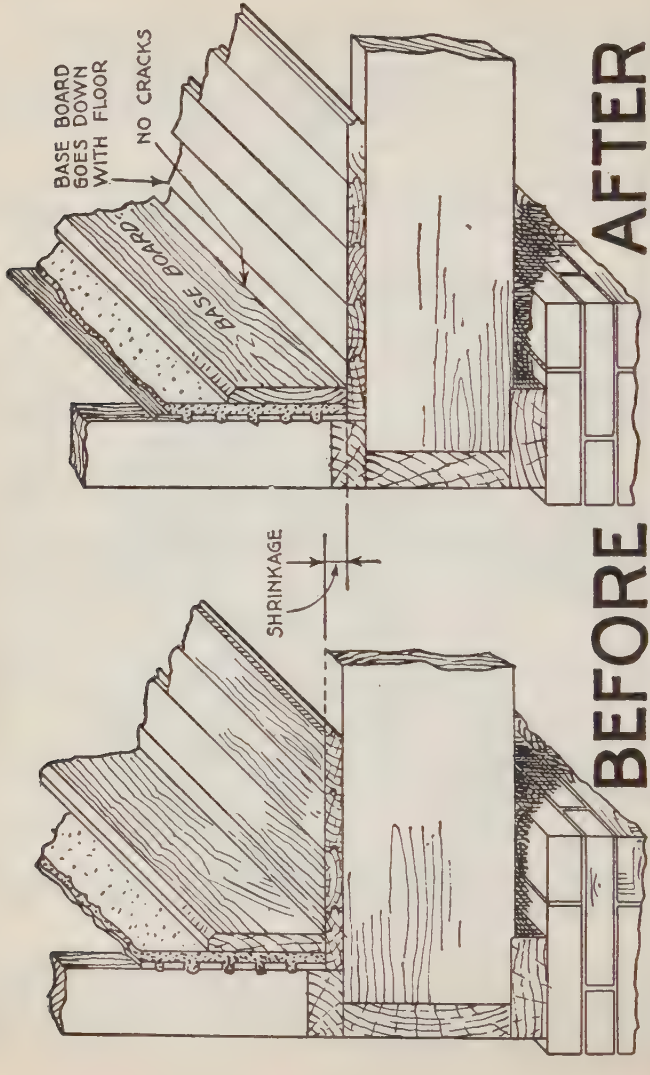
Owing to the difficulty of obtaining large straight timbers in long lengths, sills are sometimes built up "solid" as in figs. 1,806 and 1,807, as distinguished from the so-called *box* construction. Sills thus built up have about 75% of the strength of solid timbers of the same size.

Of the various open type built-up contraptions called sills, there are numerous forms consisting of a beam (usually of same cross-section size

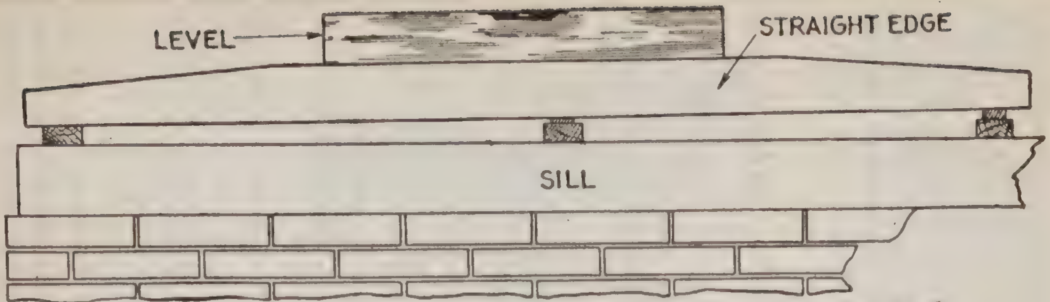


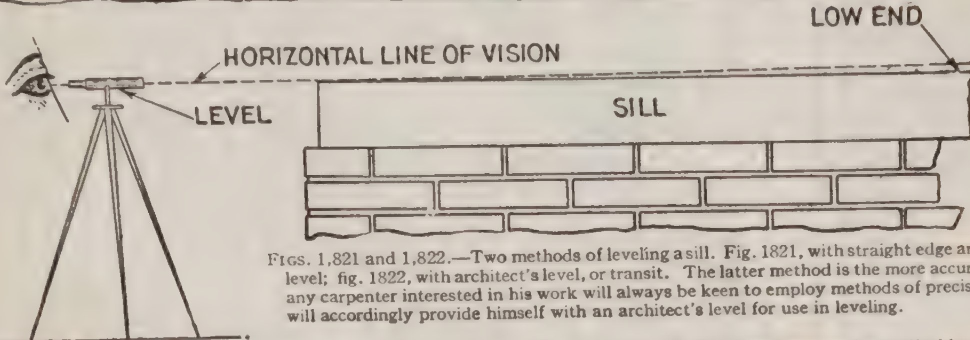
FIGS. 1,817 and 1,818.—Built-up T sill with flooring and base board in place *before* and *after* shrinkage. *See that crack?* Such cracks will invariably occur with such sill construction unless the lumber has been thoroughly well seasoned because there is no provision for shrinkage.

as the floor beams, or thicker) resting upon a similar horizontal member called the *bed plate*. Sills of such construction may be called L or T sills, according to the location of the beam on the bed-plate and resulting resemblance to these letters.



FIGS. 1,819 and 1,820.—Box sill with flooring and base board in place *before* and *after* shrinkage showing how the base board goes down with the flooring as the wood shrinks crosswise, thus maintaining the same relative position of parts regardless of shrinkage and in this way preventing any crack between base board and flooring.



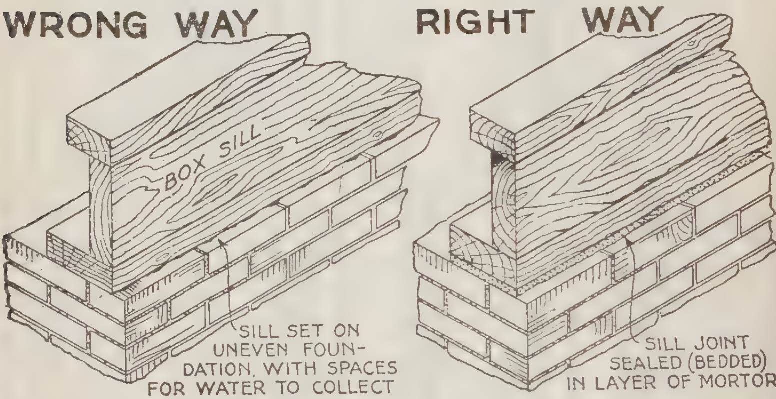


FIGS. 1,821 and 1,822.—Two methods of leveling a sill. Fig. 1821, with straight edge and spirit level; fig. 1822, with architect's level, or transit. The latter method is the more accurate and any carpenter interested in his work will always be keen to employ methods of precision and will accordingly provide himself with an architect's level for use in leveling.

Figs. 1,809 to 1,816 show several types of such sills, and figs. 1,813 and 1,814 two forms of so called box sills. The function of the beam is to carry the load, and that of the bed plate to distribute the load over surface of the top of the foundation and to provide a footing for the joists.

The various sills shown in the accompanying cuts may be divided into two classes, according as they do, or do not provide for shrinkage. This is an important item as the sills, joists, studs and other rough lumber come generally almost direct from the mill without being seasoned.

Now as lumber seasons it will shrink from ¾ to 1 inch to the foot in width, while the shrinkage along its length is scarcely perceptible. Accordingly, when the studs have their footing on the bed plate as in fig. 1,817, with flooring laid out to studs and base board fitted close to floor and nailed to studs, it looks all right and is all right until the lumber begins to shrink. Remembering that the shrinkage takes place crosswise, it must be evident that as the joists shrink they will take the floor down with them, leaving the base board suspended on the studs with a crack from ½ to ¾ inch between the baseboard and flooring as in fig. 1,818.



FIGS. 1,823 and 1,824.—Wrong and right way to set sills, especially built-up sills. The joint between the bottom of the sill and top of foundation should be thoroughly ceiled to prevent entrance of moisture or water which will quickly rot the sill. Moreover, when the joint is not ceiled cold air will come in through the cracks—also insects.

This may be avoided by footing the studs above the sill as in figs. 1,813 to 1,816.

Evidently, when shrinkage takes place in the floor joists and sill beam, the studs go down with them, thus keeping base board, floors, doors, etc., in their original relative positions.

Setting the Sill.—After the girder is in position, the sills are placed on top of the cellar walls, rounding side up and hollow side out, and are very carefully fitted together at the joints and

leveled throughout. The last operation can either be done by a sight level, or by the following method:

Place seven-eighths inch blocks at intervening distances on the length of each side, also one at either end, and set a long parallel straight edge on them, also set a true level on the upper jointed edge of the straight edge. The sill must be wedged up, or lowered down until the air bubble in the level tube is exactly

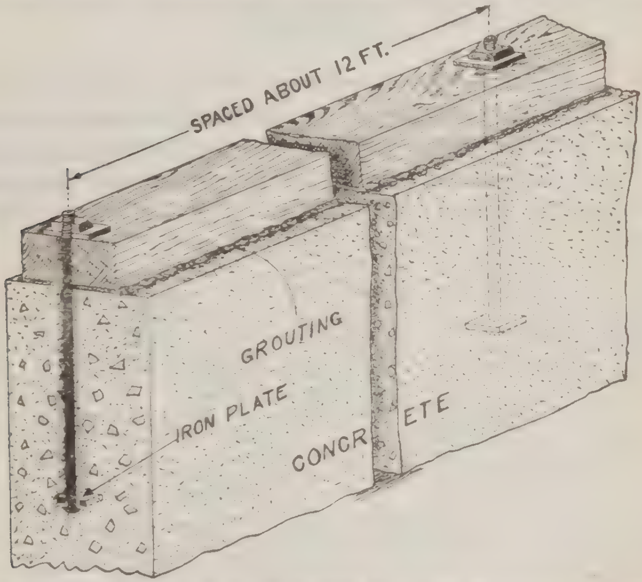


FIG. 1.825.—First class setting of solid sill showing sill ceiled with grouting and secured by anchor bolts.

in the center, and each piece must also be wedged up or lowered till the blocks all touch the bottom edge of the straight edge. In all cases the whole length of the sill should, if possible, bear solidly on the stone work, and may either be bedded in mortar or made up solid with chip pieces of slate, stone wedges or

furrings, and these should not be inserted less than two feet apart.

After the sill has been leveled as just directed it should be sealed under by forcing a web of strong mortar under it from both sides to insure a tight closure as well as to hold the sill and wedgings under in place.

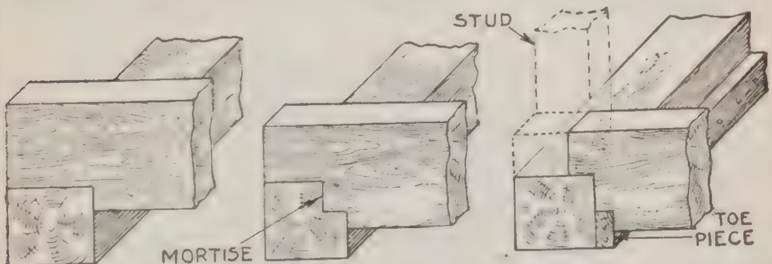
> The wedges shall be set far enough under from face of sill as not to protrude the mortar, especially outside where the sheathing is to be scribed to wall and fit neat to sill.

Sills to rest on a wall of masonry should be kept up at least 18 inches above the ground, as decaying sills are a frightful source of trouble and expense in wooden buildings, sheathing, papering and clapboarding covering them should therefore be very carefully done to effectually exclude all wind and wet weather.

CHAPTER 39

Joists

After the girders and sills have been placed the next operation consists in *sawing to size the floor beams or joists of first floor and placing them in position on the sills and girders.*

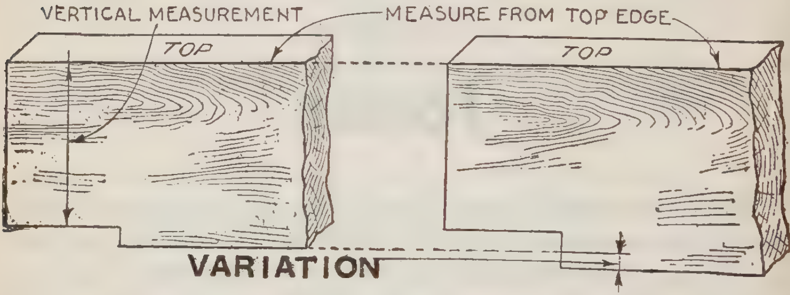


FIGS. 1,826 to 1,828.—Various joints of joist with solid sill. Fig. 1,826, cheap construction; fig. 1,827, first class but expensive construction with mortise where it is desirable to reduce height above sill; fig. 1,828, toe piece substitute for mortises. Although the joist here need only to reach to the stud, but additional strength is secured if it be extended to the outside of stud so that it may be spiked to stud as indicated by the dotted lines.

An important consideration is the method of resting the joists upon the sills and girders. With built up sills this depends upon the form of the sill, but when solid sills are used there are several forms of joints available as shown in figs. 1,826 to 1,828.

Because of the great variation in the size of timbers it is necessary to always size the joists to 1 inch narrower than the timber, so that their upper edges will be in alignment. This sizing should be done from the top edge of the joist as shown in figs. 1,829 and 1,830.

When the joists have been cut to dimension they should be



FIGS. 1,829and 1830.—Two joists cut or notched for joint with sillshowing necessity of taking the vertical measurement from the top or floor edge because of the *variation in width of the timbers*.

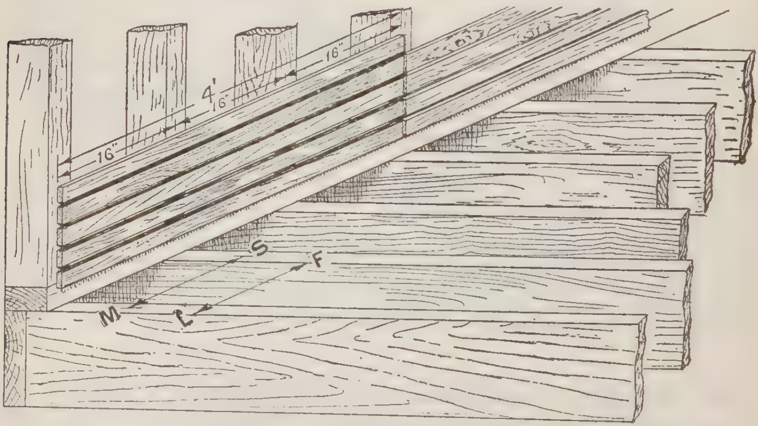


FIG. 1831.—Spacing of joists illustrating why they are spaced 16 ins. "between centers." In laying out it is not necessary to scribe the marks at the centers as MS, but the distance is more conveniently measured from the sides as LF. If the space to be filled be not a multiple of 16 inches the variation should all come at one side of the room so that the laths will not have to be cut more than necessary.

placed upon the sill and girders, and *spaced* 16 *inches between centers*, beginning at one side or end of a room. This is done to avoid waste in lathing.

Since the laths are 4 feet in length, which is a multiple of 16 inches, their ends will come over the studs, as shown in fig. 1,831, when the joists are spaced 16 inches because the studs are spaced the same as the joists. This spacing should be done with some precision. A good method is to lay off the spacing on a plank, and accurately space each joist by "tacking" plank to the joists as in fig. 1,832. This tacking consists in driving the nails only partially in, leaving the heads projecting so that they may be withdrawn later with a claw hammer.

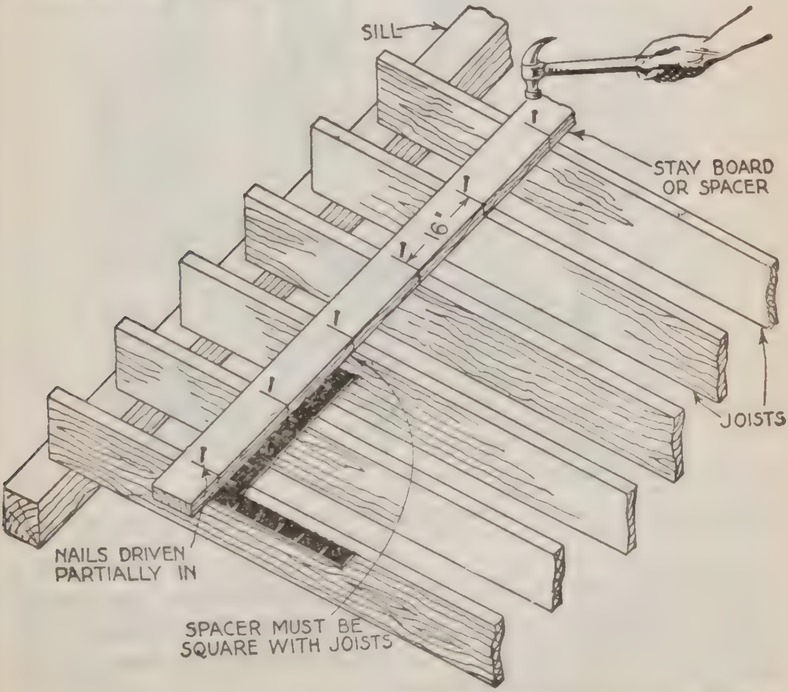


FIG. 1,832.—Joists in place on sill illustrating how they are spaced and retained in position until permanently fastened to studs.

A floor joist should be nailed against the outside walls (the walls parallel with the joists) to provide nailing surface for the floor boards where the type of sill used does not provide such surface.

Figs. 1,833 and 1,834 show types of sill which require, and do not require a special end joist for nailing surface.

Bulging.—To prevent joists springing sideways under load

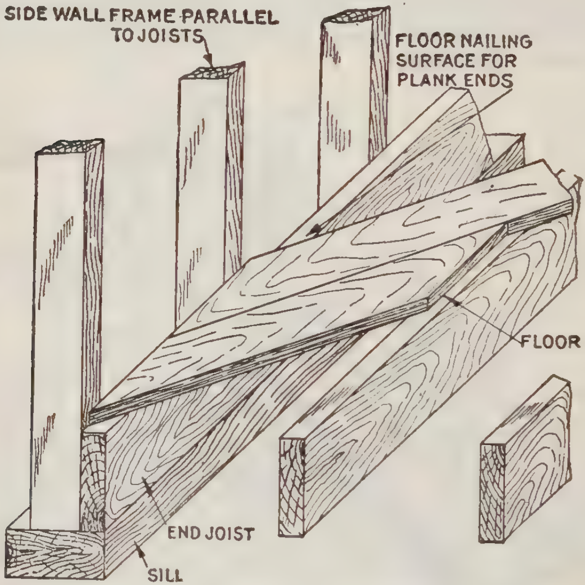


FIG. 1,833.—End joist nailed against studs to provide nailing surface for the ends of the floor planks.

which would reduce their carrying capacity, *they are tied together diagonally by* 1×3 or 2×3 strips, this reinforcement being called bridging, the 1×3 ties being used for small houses and the 2×3 stock on larger work.

Rows of bridging should not be more than 8 feet apart.

Bridging pieces may be cut all in one operation with a mitre box, save for the uneven length pieces at the ends, or the more common method shown in fig. 1,835 may be employed. Bridging would be put in before floor is laid fastened with two nails at each end. Before the bottom end is nailed the floor joists should be forced up until it has a crown in it.

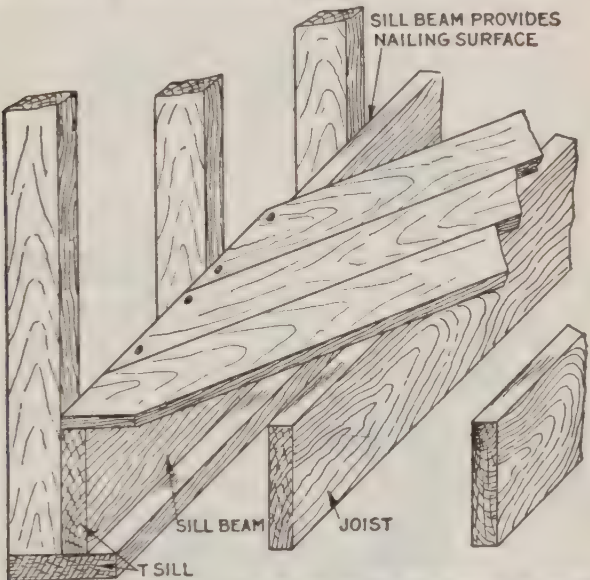


FIG. 1,834.—One of several types of built up sill which do not require an end joist to provide floor nailing surface.

A more rigid (less vibrating) floor is had by cutting in solid 2 inch joists of the same depth. They should be cut perfectly square and a little full, say 1/16 inch of the inside distance between joists. First set one in every other space, then go back and put in the intervening ones. This prevents spreading and allows driving these second ones home with the strain alike in both directions.

Headers and Trimmers.—The foregoing operations would complete the first floor framework in rooms having no framed openings technically called *well holes*, such as openings for stairways, chimneys, elevators, etc.

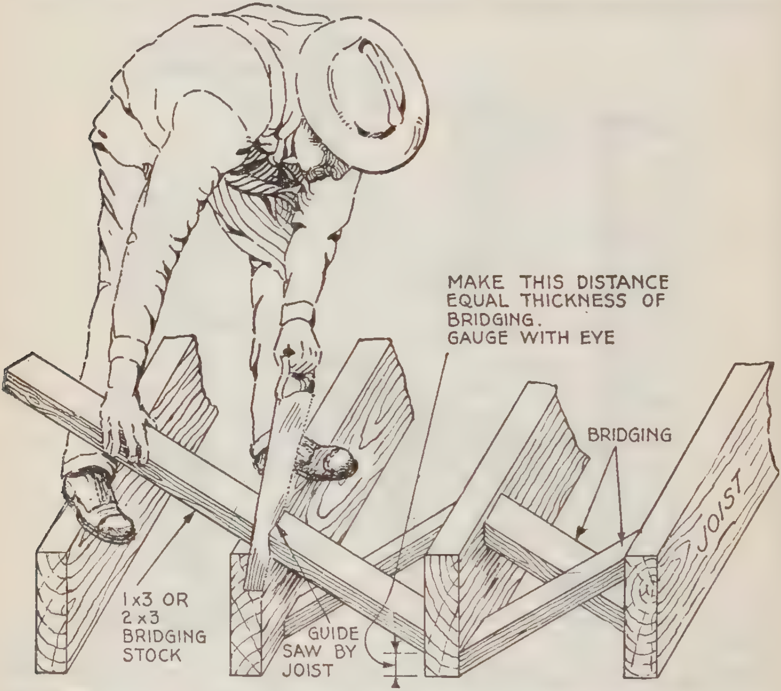


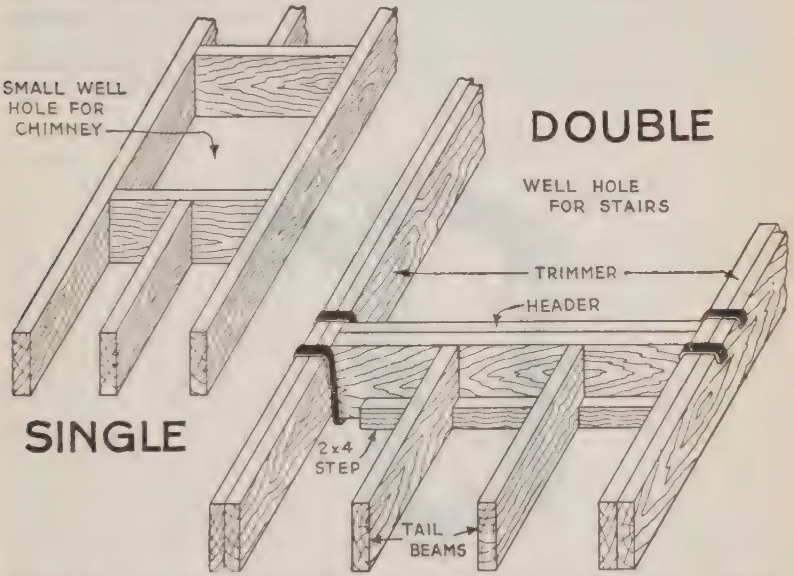
FIG. 1,835.—Method of sawing bridging on joists. ***In starting*** cut proper bevel on end of stock, and place in position as shown with lower edge of bevel at a distance above lower edge of joist equal to thickness of bridging as judged by eye. Saw vertically along joist as shown, using joist as a guide for the saw. This cuts the piece to the desired length and bevel and at the same time gives the lower bevel for the next piece.

By definition a **header** is a *short transverse joist which supports the ends of one or more cut off joists (called tail beams) where they*

are cut off at a well hole. A **trimmer** is *a carrying joist which supports an end of a header.*

When there are well holes the headers and trimmers around them must be placed first.

It will not very often occur that mortise and tenoning will be required for well holes in balloon frame construction, but when it does, care must be



FIGS. 1,836 and 1,837.—Single and double header and trimmer construction around "well holes."

exercised to have the work come right and the proper way is to place and nail one trimmer beam first in exact position on the sill and its like (fellow) joist opposite it, loose. This done, the framed header or headers may have its tenons placed in the mortises in the pair of trimmers and the loose trimmer made parallel to the one that is nailed, that is, it must be the same distance apart at the sill end as the length of the header. When there are two headers, paralleling to sill is not necessary. Always square the header from the trimmer.

The practice of first placing all trimmer and header beams for stairs, chimneys, etc., should always be followed because the openings are then sure to be in their proper positions.

Having thus framed the well holes, the remaining joists are then carried in and framed with proper spacing as indicated in the plans.

Often, in balloon framing well holes are cut out after joists are in place. When not supported below spike a joist to those that are to be cut, with the end overlapping the one next not to be cut. Always allow for the thickness of the header or double header so that when spiked into place the opening will be the required size. Sometimes the header is longer than that required for ordinary stairs, or has to carry a partition or other extra load; then it

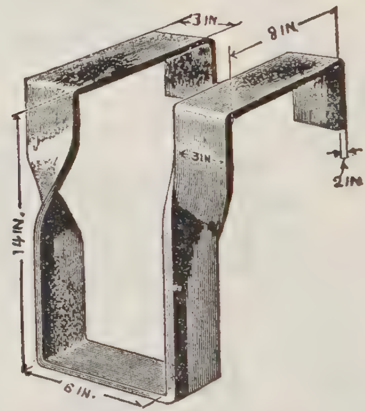


FIG. 1,838.—Builder's stirrup or joist hanger. ***It consists of*** an iron or steel strap so constructed that it hangs over the trimmer or header and forms a footing for the header or tail beams, being much stronger than mortise and tenon, or spiked joints, as no wood is cut away, or nails depended upon to carry the load.

is good practice to use wrought iron strap hangers of a size adequate to the load, as shown in figs. 1,837 and 1,838; sometimes these hangers are used on both headers and tail beams.

This construction is stronger than spiking, or mortise and tenoning.

The following table gives the usual sizes of these hangers carried in stock.

Standard Stirrups or Joist Hangers

Size of Hanger		Size of iron						
		$\frac{3}{16}\times1\frac{3}{4}$	$\frac{1}{4}\times2$	$\frac{3}{8}\times2$	$\frac{3}{8}\times2\frac{1}{2}$	$\frac{3}{8}\times3$	$\frac{3}{8}\times3\frac{1}{2}$	$\frac{1}{2}\times4$
4 × 10	× 2	.....	.....					
4 × 12		.....	.....					
4 × 14		.....	.....					
4 × 10	× 4	.....	.....	.....	.....			
4 × 12		.....	.....	.....	.....			
4 × 4		.....	.....	.....	.....			
6 × 12	× 3		.....	.....	.....	.....	.....	
6 × 14			.....	.....	.....	.....	.....	
6 × 10	× 6			.....	.....	.....	.....	
6 × 12				.....	.....	.....	.....	
6 × 14				.....	.....	.....	.....	
6 × 16				.....	.....	.....	.....	
8 × 10	× 8			.....	.....	.....	.....	.....
8 × 12				.....	.....	.....	.....	.....
8 × 14				.....	.....	.....	.....	.....
8 × 16				.....	.....	.....	.....	.....
10 × 12	× 6				.....	.....	.....	.....
10 × 14					.....	.....	.....	.....
10 × 16					.....	.....	.....	.....
10 × 12	× 8				.....	.....	.....	.....
10 × 14					.....	.....	.....	.....
10 × 16					.....	.....	.....	.....

At this stage, either a temporary floor should be laid (using the flooring material rough side up, or in case there will be no interference by the side wall construction this rough floor may be laid permanently.

With a built up sill such as shown in fig. 1,839, it is necessary to *permanently* lay the rough floor before the wall framework can be erected. This

operation is shown in fig. 1,839. It is no drawback to permanently lay the rough floor before erecting the wall framing when the construction will permit, but an advantage as the flooring then has to be laid only once and the danger of falling through the joists with carelessly laid temporary floor avoided. This danger arises when plank ends project over a joist so that when a workman steps on the end of such plank his weight presses it down and causes him to fall between the beams. In every case the end of each floor plank should rest on a joist.

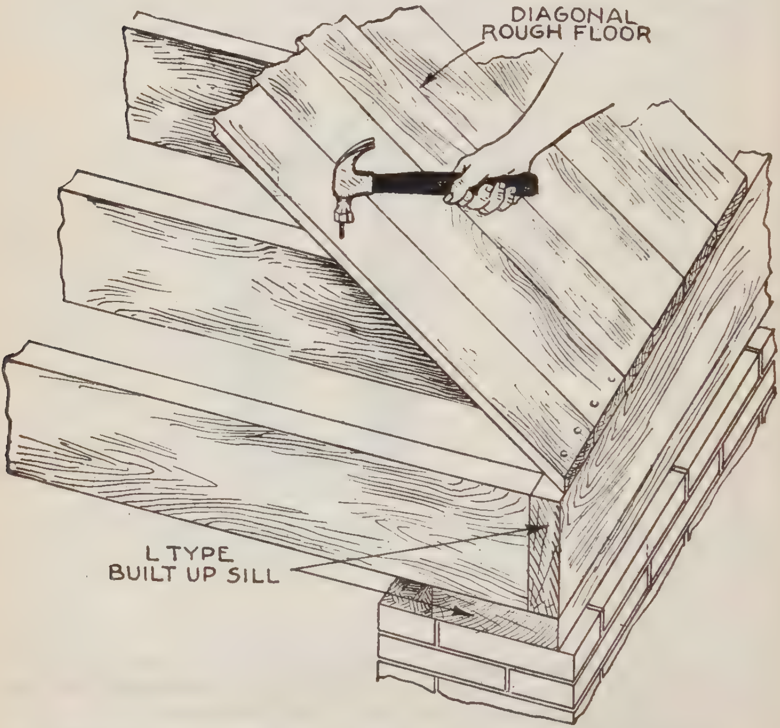


FIG. 1,839.—Diagonal rough floor being permanently laid before erecting wall framework. The type sill here used not only permits but requires that the rough floor be permanently laid at this stage of the work, because the studding shoe rests on top of it.

CHAPTER 40

Framework of the Outer Walls

The term "framework of outer walls" here includes the *corner posts, girts, ribbands, studding and plate forming the outer framework from sill to rafters.*

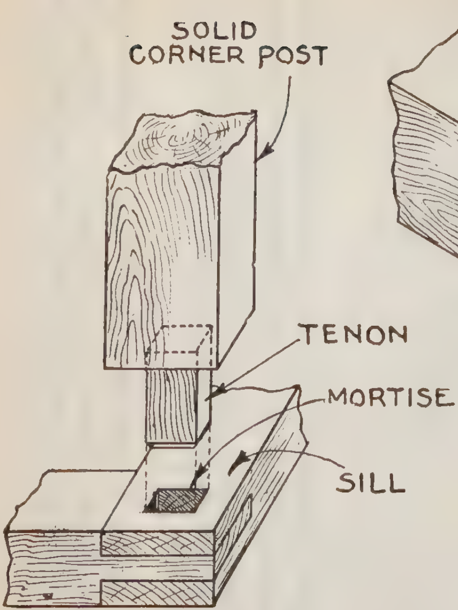
Whether the outer walls shall be framed before the rough or sub-floor of the first story is laid will depend upon the type of sill as already explained. Some sills, as for instance the box sill shown in fig. 1,839, require the rough or sub-floor to be laid first because the studding shoe rests on this flooring as shown.

In general, where the construction permits, it is advisable to permanently lay the rough floor before erecting the wall studding, to avoid "traps" and save the time of laying and removing a temporary floor. It also furnishes a surface on which to work and a sheltered place in the cellar for storage of tools and materials.

Solid Corner Posts.—In the full frame system of house framing, *the corner posts are made from solid timbers* (*not built up*).

In such construction the frame is put together on the rough floor and raised in sections, whereas in balloon framing the corner posts and each stud are raised separately.

A solid corner post must have a tenon cut at the lower end for the joint with the sills as in fig. 1,840, and two mortises cut at the proper joint for the tenons of the *flush* and *sunken* girts as in fig. 1,841.



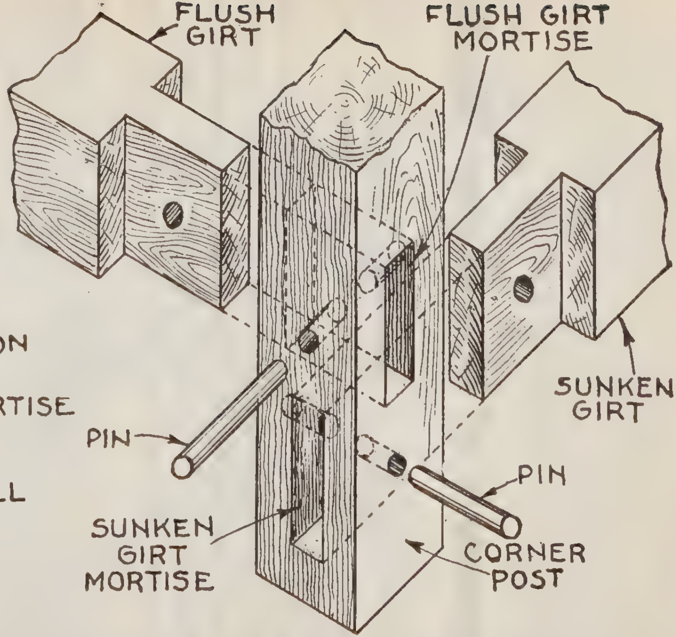


FIG. 1,840.—Lock mortise and tenon joint of corner post with the sills. ***The principal object*** of the tenon is to prevent the post slipping off the sill, but when made long enough to project into both sills it also serves to lock them together.

FIG. 1,841.—Mortise and tenon joints of flush and sunken girts with plain shoulders. A satisfactory construction where most of the load coming on the girt is supported by the studs.

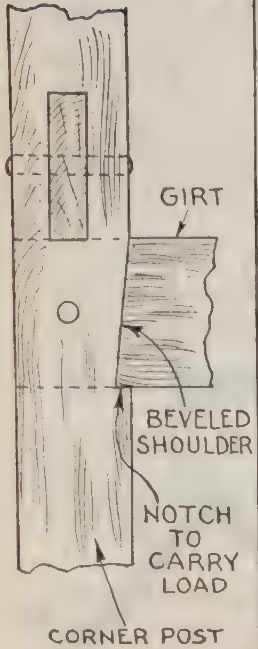
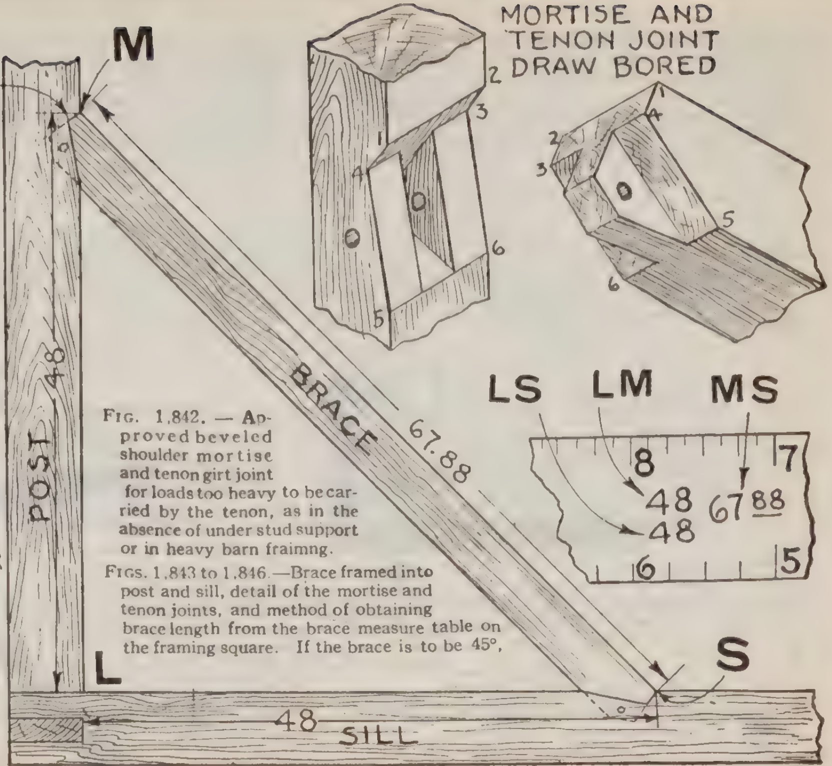
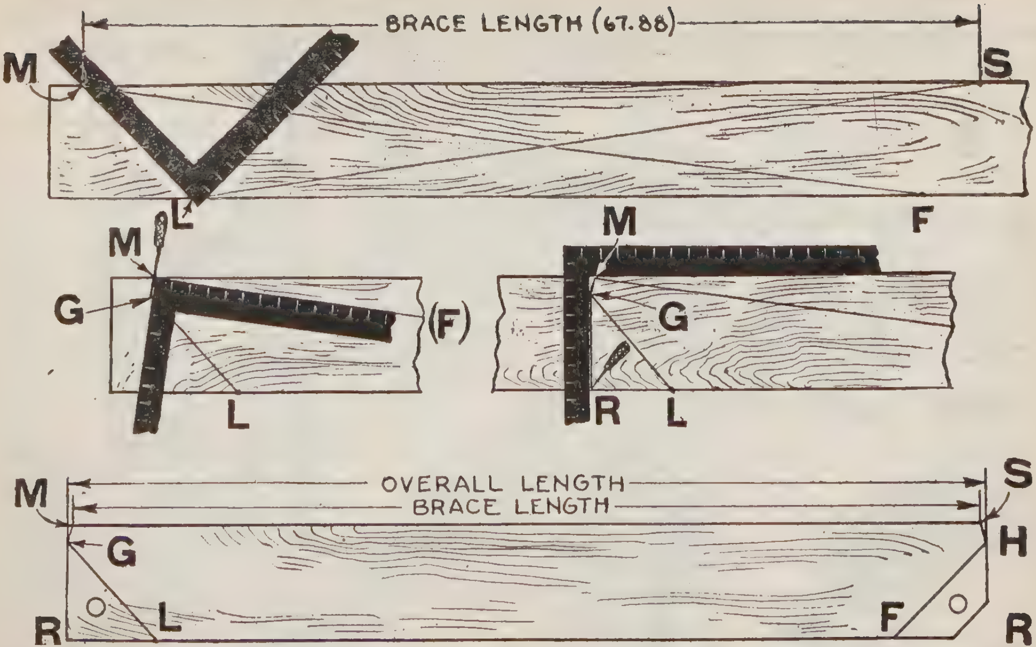


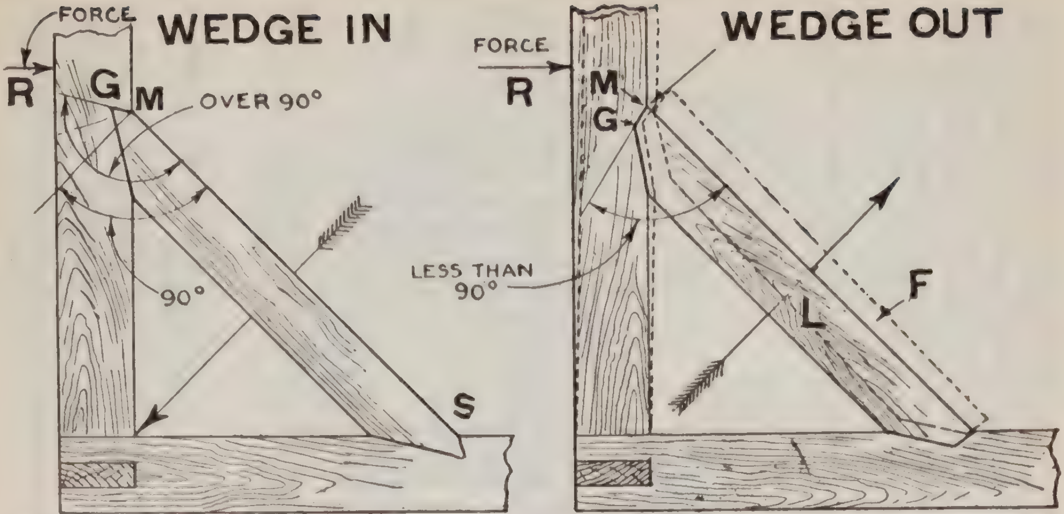
Fig. 1,842. — Approved beveled shoulder mortise and tenon girt joint for loads too heavy to be carried by the tenon, as in the absence of under stud support or in heavy barn fraimng.



Figs. 1,843 to 1,846.—Brace framed into post and sill, detail of the mortise and tenon joints, and method of obtaining brace length from the brace measure table on the framing square. If the brace is to be 45°, that is, to span equal distances on post and sill, say 48 ins. as in fig. 1,843, find upon tongue of square the figures shown in fig. 1,846. The letters (**LS, LM, and MS,**) correspond with those in fig. 1,843, which explains what the figures represent.



FIGS. 1,847 to 1,850.—Method of laying out a corner post brace. On the timber selected for the brace, lay off (fig. 1,847) MS, 67.88 length of brace as read from the square in fig. 1,846. Since this is a 45° brace, place square at M, so that equal distances on tongue and body register with edge of timber and mark point L. Similarly find F, and scribe lines MF, and LS. In fig. 1,848, place square on line MF, (just drawn), and scribe MG, say 1 in. long; join GL. In fig. 1,849, with square in position shown, square off timber at G, by scribing line GR. MGL, is outline of shoulder and GRL, tenon. The other end of brace is laid out in a similar manner. Fig. 1,850, shows brace cut to the scribed lines on end, and similarly cut on right end, the point of the tenon being champered at R parallel to shoulder FH.



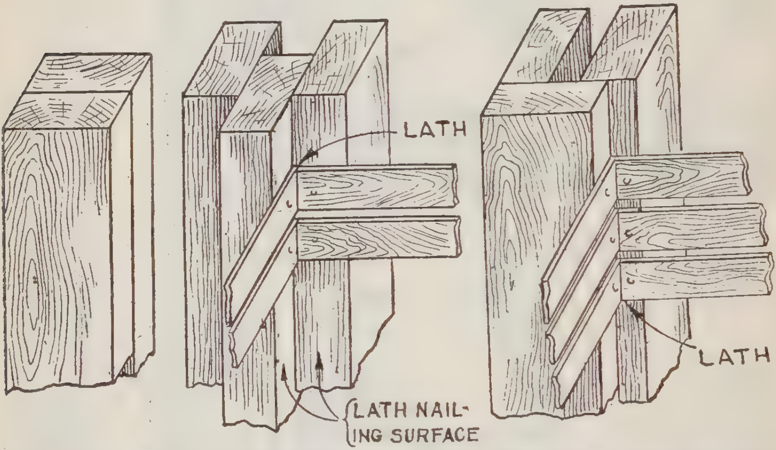
FIGS. 1,851 and 1,852.—Why the end shoulder MG is made more than 90° with the side of the brace. When MG, is laid out as in fig. 1,851, it makes an angle a little over 90° with the side MS, (fig. 1,843) of the brace. Now in fig. 1,851, if a force R, due to wind or other cause come on the building it will tend to force the post to the right and wedge in the brace at both ends. Again, when the shoulder MG, makes less than 90° with the side of the brace, as in fig. 1,852, and a force R, be applied the post would tend to move from position L, to position F, forcing the brace out of its bearings as from position L, to position F. This would actually happen if the draw pins or tenons broke.

Note that these are plain girts; for heavy loads a girt having a beveled shoulder resting on a notch cut into the post to relieve the tenon of the load is used as shown in fig. 1,842. In addition to these girt mortises, six other mortises must be cut in the post for the braces: two near the sill end, two below and above the girts, and two near the plate end.

In best work a tenon is cut on the plate end for a mortise and tenon joint with the plates similar to the joint at the sill end, though usually the plates are simply spiked to the post. It is thus seen that this solid full frame construction requires an excessive amount of labor, the present high cost of which together with the expense and difficulty of obtaining the heavy timbers precludes much work of this kind.

The construction of the braces is shown in figs. 1,842 to 1,850.

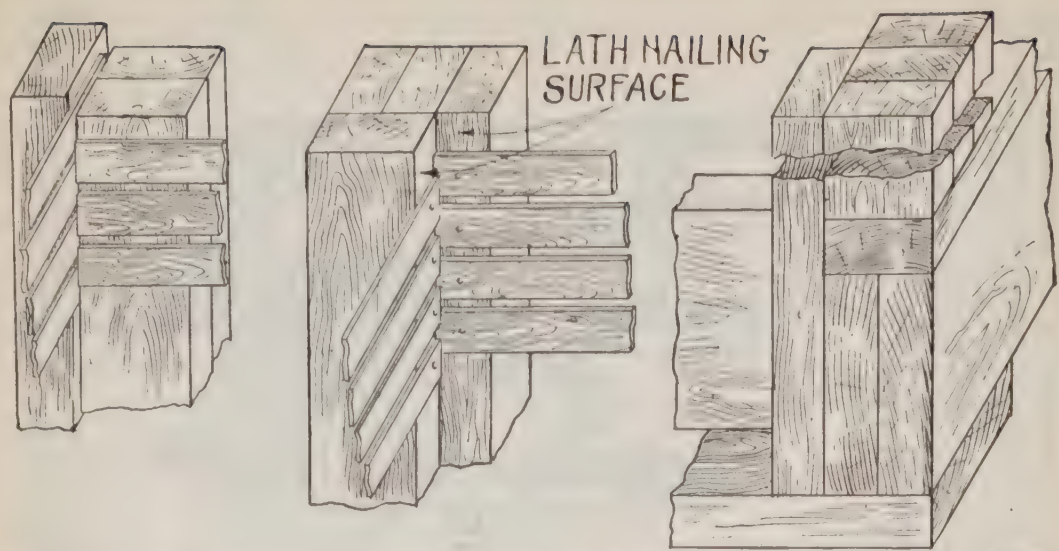
All mortise and tenon joints except at the corner post ends are draw bored.



FIGS. 1,853 to 1,855.—Various built-up corner posts. Fig. 1,853, so called corner post made of two studs. Fig. 1,854, three-piece "Y," form; fig. 1,855, three-piece "U," form. A few laths are shown in position in the figures to indicate the lath nailing surface.

An inch auger bit is generally used. The pins should be one inch diameter and made of oak for a spruce or yellow pine frame.

When there are intermediate posts they are mortised and draw pinned into the sills. In laying out the mortises and other cuts for the sills, corner posts and girts, very accurate measurements should be taken and verified before tooling the pieces. The importance of this must be apparent, considering the loss of time and material if a piece be spoiled owing to error in measurements.



FIGS. 1,856 to 1,858.—Various built-up corner posts. **Fig. 1,856, three-piece solid form. An objection to this type is the fact that** the post must be furred after the lather has placed the lath upon one side of the room. Fig. 1,857, four-piece "L" form, a substantial post with good nailing surfaces for the lath. Fig. 1,858, method of joining the four-piece post (shown in fig. 1,857) with sill, one piece projecting down to the bed plate, giving good spiking surface with the sill beams; a good substantial construction.

Built Up Corner Posts.—There is a multiplicity of ways in which corner posts may be built up, using studding or larger sized pieces. Some carpenters form corner posts of two 2×4 studs spiked together to make a piece having a 4×4 section. Except for very small structures, such a flimsily built up piece could not be regarded

as a corner post save by a stretch of the imagination. Figs. 1,853 to 1,858 show various arrangements of built up post commonly used.

Balloon Bracing.—In balloon framing the bracing may be temporary or permanent. By temporary bracing is meant strips nailed on as in fig. 1,859 to stay the frame during

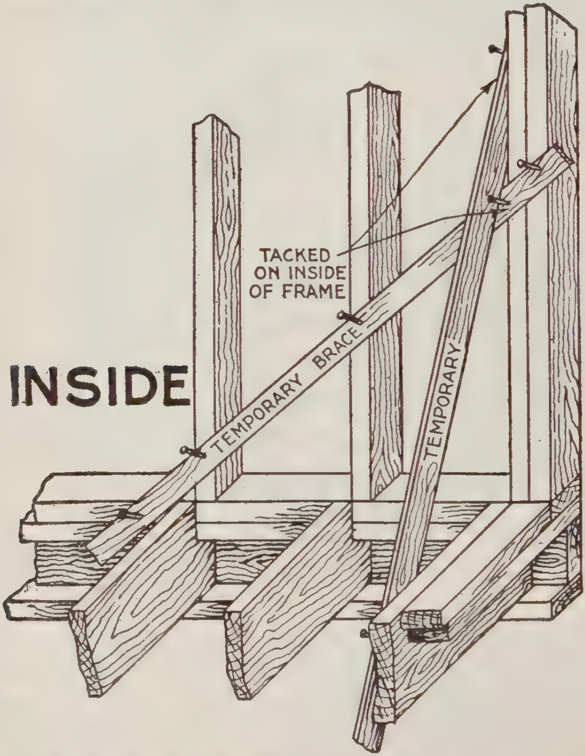


FIG. 1,859.—Temporary balloon frame braces. *The temporary brace* is tacked on the frame from the inside to stay the structure during construction. The nail heads are left projecting a little so that they may be withdrawn with a claw hammer in removing the brace after the siding is on. Such construction should not be permitted.

construction and which are removed when the siding is put on, the latter being depended upon for stiffness. Such construction cannot be too strongly condemned and no contractor or carpenter with any regard for his reputation will tolerate such makeshift method.

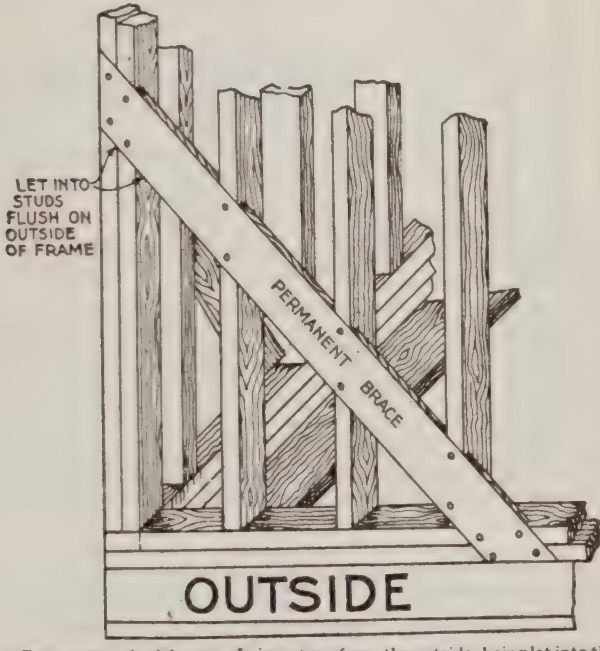
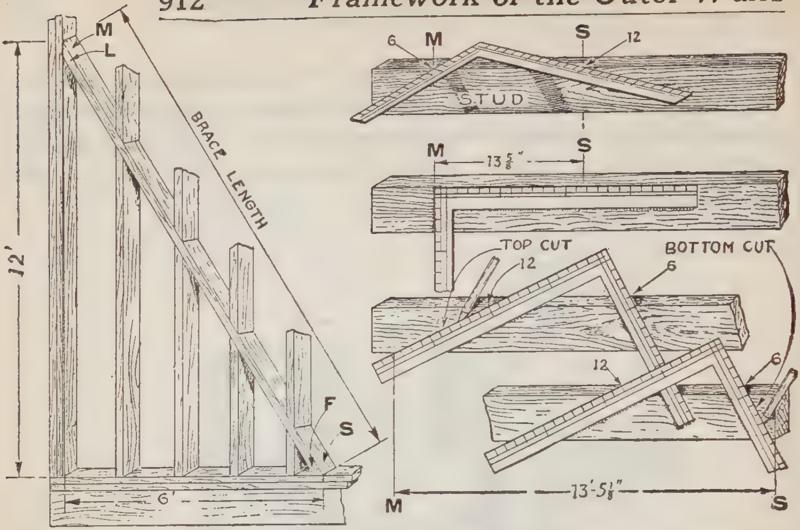


FIG. 1,860.—Permanent *plank* brace. It is put on from the outside, being let into the studs so that it is flush with the outside of the frame. These views do not show true length of such braces, being shortened here and also in fig. 1,861, to bring out details more clearly.

Permanent braces are of two kinds: plank and stud, as shown in figs. 1,860 and 1,861. The latter being of heavier timber is naturally the stronger.

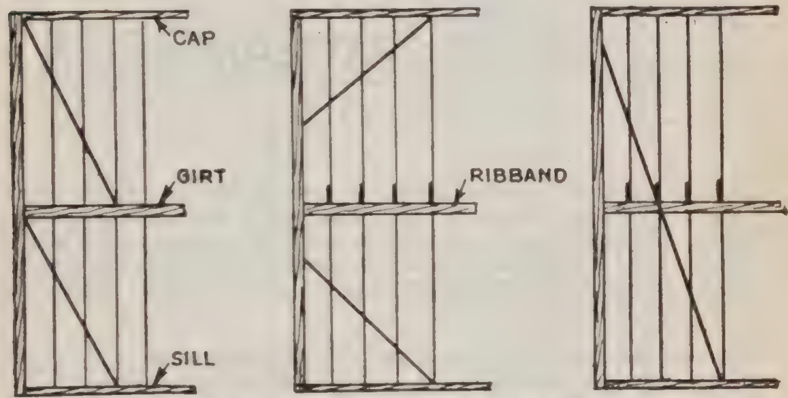
The layout of a brace of unequal span by direct measurement with the



FIGS. 1,861 to 1,864.—Stud brace as used on half frames and sometimes in balloon frames, and method of obtaining length by direct measurement with steel square. Since these braces are of unequal pitch and of lengths beyond the range of the brace measure table, place square on edge of timber so that the lengths of the two spans taken on tongue and body on scale of 1 in. =1 ft. register with the edge of the timber, as in fig. 1,862, giving points M, and S. The lengths 6 ins. and 12 ins. correspond to the 6 ft. and 12 ft. spans marked in fig. 1,861. Measure the distance MS, with square as in fig. 1,863, obtaining the length of beam 13 5/8 ins. (+) on square which corresponds to 13 ft. 5 ins. (+) on scale 1 in. = 1 ft. In measuring the point S, comes between the 5/12 and 6/12 divisions, (each of these divisions representing 1 in.), and as judged by eye in amount corresponding to 1/8 in. hence the reading for beam length is 13 ft: 5 1/8 ins. Fig. 1,864 shows method of laying out the top and bottom cuts which needs no explanation.

NOTE.—***Posts and studding.*** Some carpenters and builders form their corner posts in balloon frames of two 2×4 joists spiked together to make 4×4 sticks, as it were. Some use 4×4 scantling, and others make them of one stick of 4×6. The posts and studding can be laid out from one pattern, which should be first framed just as the studs and posts will be. This can either be made out of a piece of 7/8-inch pine or a 2×4 stud, and it must be laid out for the gain for the girt strip or ribbon and squared at the top and bottom ends. The pattern should be perfectly straight on edge and be without wind. When a good pattern is made the posts are first placed on the saw horses and laid out. The ends are also sawed off square and the gain is sawed and chiseled out for the strip. Next the wall studs are placed on their edges on the saw horses in quantities of 6, 8 or 10 at a time and the edges squared over from the pattern. Careful carpenters use two patterns, placing one each side of a number of joists, when laid on the horses, and then squared across from end to end, or from gain to gain, thus making sure that they will be exactly right. Studding should be laid out on the rounding edge, so that the hollow edge will come on the outside or *face* side of the wall. When the edges are marked the faces are squared over. Some prefer to lay the pattern on each piece singly, and mark the face of stud at once, thus avoiding the necessity of squaring over the edge. This practice undoubtedly saves time, but the sawing must be done by good workmen or the joints won't be square.

steel square using a scale of 1 inch = 1 foot is shown in figs. 1,861 and 1,864, and the marking of top and bottom cuts in fig. 1,864. Since balloon braces are considerably larger than full frame braces they are beyond the range of the brace table on the square. Moreover, being of unequal span the brace table does not apply, hence the length is conveniently found by the direct measurement. For this purpose the inches on the outer edge of one side of the square are divided into 12ths, hence on a scale of 1 inch = 1 foot, then each division on the square will represent an inch—the fraction of an inch being gauged by eye.



FIGS. 1,865 to 1,867.—Various brace arrangements in half, and balloon frames. Fig. 1,865, half frame with sill and girt braces; fig. 1,866, balloon frame with sill and cap braces; fig. 1,867, balloon frame with long brace reaching from sill almost to cap.

Preparing the Corner Posts and Studding.—In laying out the posts and studs, a pattern should be used, to insure that all will be of the same length with gain and any other notches or mortises to be cut, at the same elevations. The pattern can be made out of a piece of ⅞ inch pine or a 2 × 4 stud, and it must be cut to exact length square at both ends, and the *gain* or notch for ledger board (in the case of a balloon frame) laid out at the proper elevation. The pattern should be made from a selected piece of wood having straight edges and be without wind.

If a stud be used for pattern it may be afterwards used in the building and therefore counted in with the total number of pieces to be framed, thus avoiding any waste.

After making pattern place first the posts on the saw horses and marked for sawing and chiseling from the pattern. Next the wall studs are placed on their edges on the horses in quantities of 6 to 10 at a time and marked

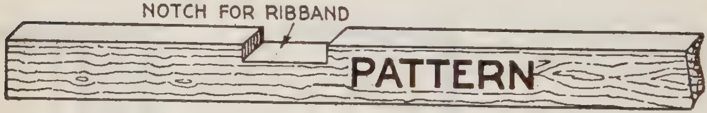


FIG. 1,868.—Pattern for laying out corner posts and studding in balloon framing.

from the patterns. Lay studding on the rounding edge so that the hollow edge will come on the outside of the wall. After marking edges, square faces. The ledger board is usually 1 × 6, and in sawing the studs for the notches to let in ledger board great care should be taken not to saw deeper than 1 inch on thickness of ledger so as not to unnecessarily weaken the studs—this is very important.

Ledger boards or ribbands, and plates are laid off by placing them alongside the layout for the studs made upon the sills and transcribing the marks

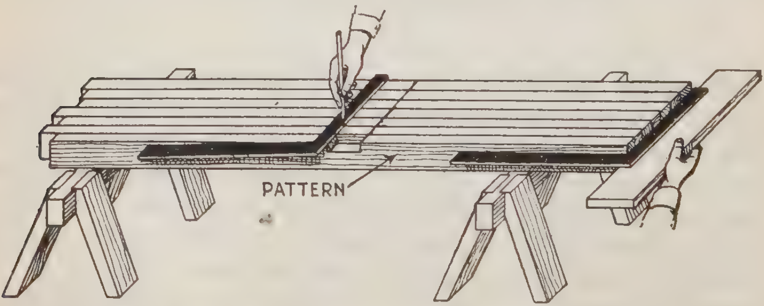
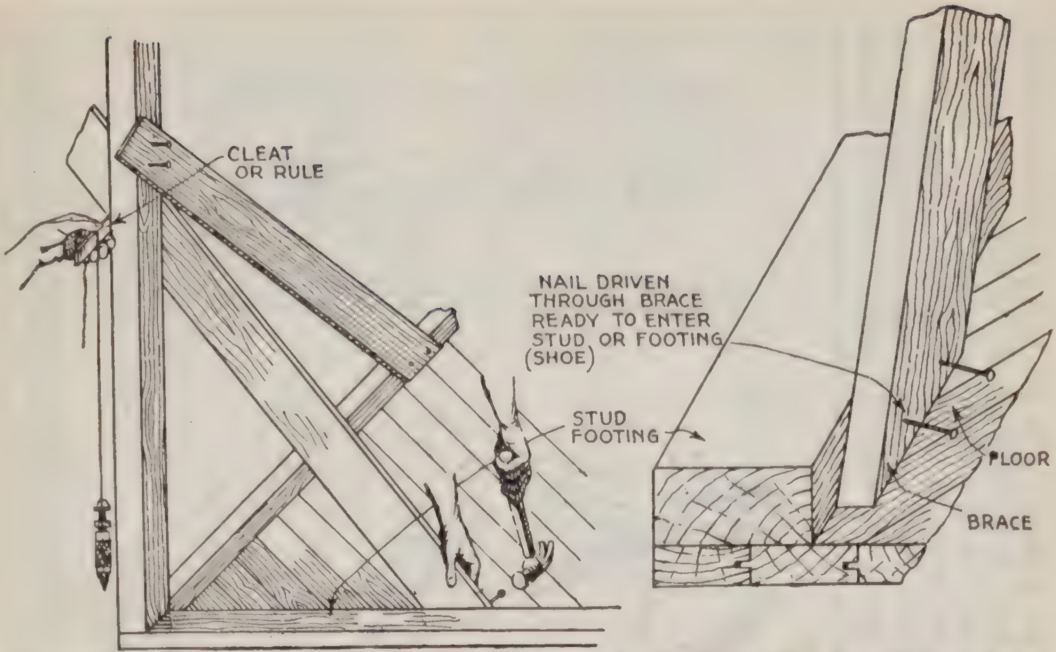


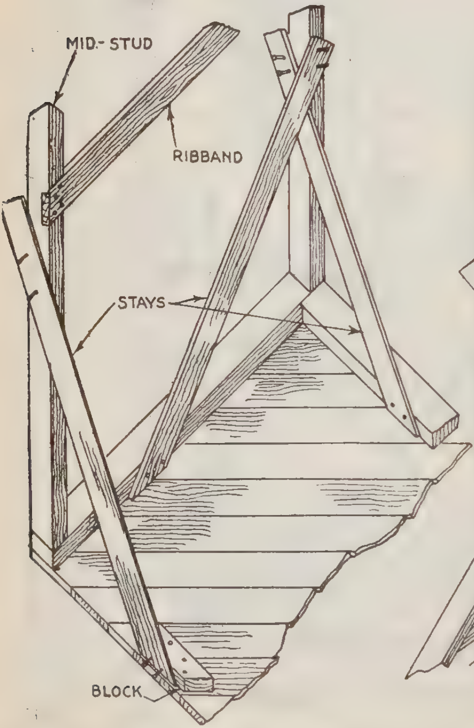
FIG. 1,869.—Studding assembled on horses with pattern in place ready to be marked for cutting by aid of square and scriber or pencil.



FIGS. 1,870 and 1,871.—Method of plumbing posts, detail of stud footing, and lower end of brace with nail driven as directed in the text. Aligning the main members of a frame is a job of precision and should be done with care to avoid later trouble in assembling the other parts.

to the ribband and plate by means of try square and pencil. Sometimes ribbands and plates are laid off by measurement as are sills. When the span is too long for any available length of ribband in laying out, provision must be made for their breaking joints upon the studs

Erecting the Frame.—If of the heavy type mortised and tenoned, it is put together on the floor and raised in sections. If of the balloon type the corner posts are first set up, plumbed, and secured in position by braces (temporary or permanent as the case may be). Next the ledger board or ribband is fastened to the corner posts, then each stud is set separately, foot nailed on the sill and to the ledger board, the latter being let into the



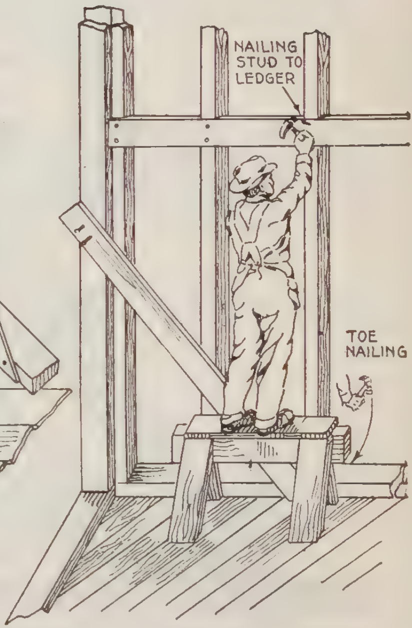
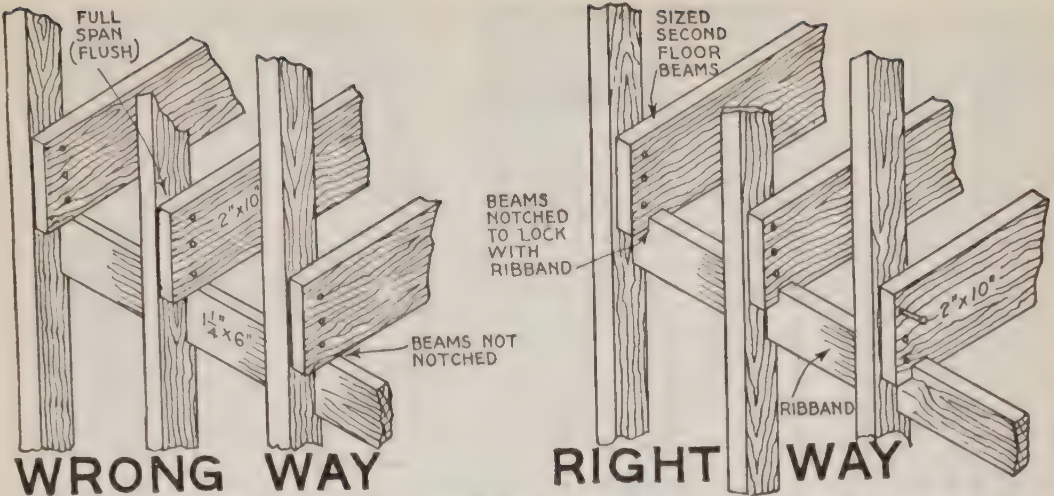


FIG. 1,872.—Corner post and intermediate stud braced with ribband in place. *The illustration shows* method of anchoring brace for intermediate stud on rough floor by nailing to block.

FIG. 1,873.—Method of erecting studs showing operations of toe nailing and nailing to ribband.

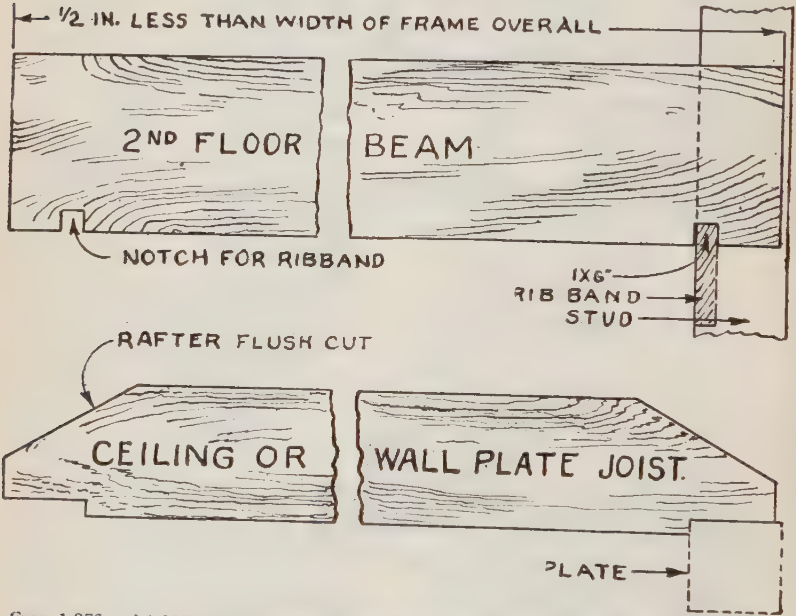


FIGS. 1,874 and 1,875.—*Wrong* and *right* way to place second story floor beams. No reputable contractor or carpenter will place beams as in fig. 1,874 with no notches in the beams to tie the opposite walls together. Fig. 1,875 shows the proper way. Each beam is notched so that when placed in position the ribband is let into it, thus securely tieing the opposite walls together. The omission of these notches cannot be too strongly condemned. It should be noted also that all floor joists should be cut ½ in. shorter than the span of the building to avoid bulging of the sheathing or siding by possible projection beyond the studs due to inaccurate measurement or vibration of the building.

stud by the notch already cut. In plumbing the corner post, a board is nailed to it as high up as a man can reach, then a second man should be ready at the foot of the board or brace with a nail already driven through the brace so that the next stroke of the hammer will cause the nail to enter sill or stud footing to which the brace is to be fastened.

When the man with plumb bob announces that the post is plumb, the other man holding brace against the sill drives in the nail, thus staying post as in fig. 1,870. The operation should be repeated with another brace on the other side of the building so that post will be plumb both ways. The studding is then fastened in place as shown in fig. 1,873.

With studding in place the next operation is to place the second floor beams these gained or notched. Three inches from the end should pull or push the whole first floor sides into perfect alignment.



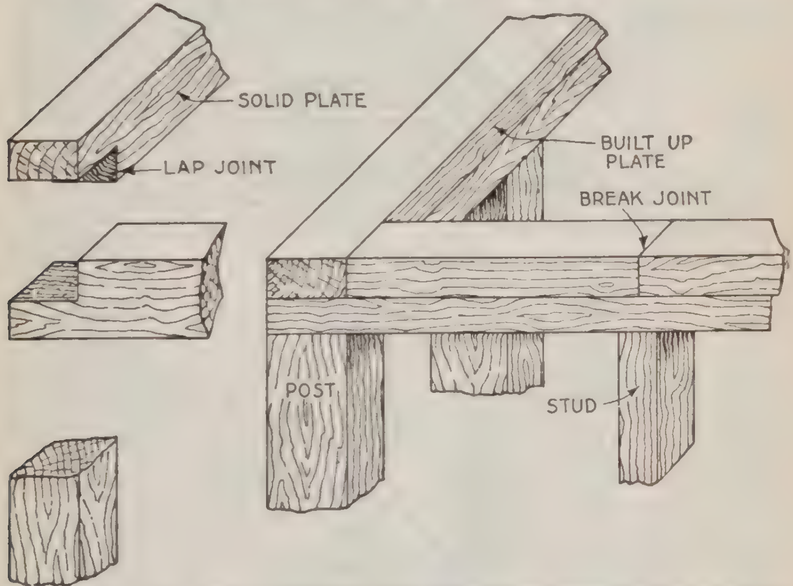
FIGS. 1,876 and 1,877.—Usual shape of second floor, and ceiling or attic beams.

In laying out and framing the second story floor beams their full length will be equal to the full width of the frame less ½ inch. The ends are kept short at each end to keep them back from the outside edges of the building. The bottom edges are notched on the line of the inside edges of the studding 1 inch wide and 1 inch deep to fit over the upper edges of the ribbon. These beams may be laid out from a pattern.

In laying out floor beams it is important to place the pattern fair with the top or rounding edge of the timber and to mark the notches at an equal distance from this top edge.

This is done to make the top edges all level so that the floor may have a level surface when the beams are placed and the flooring laid.

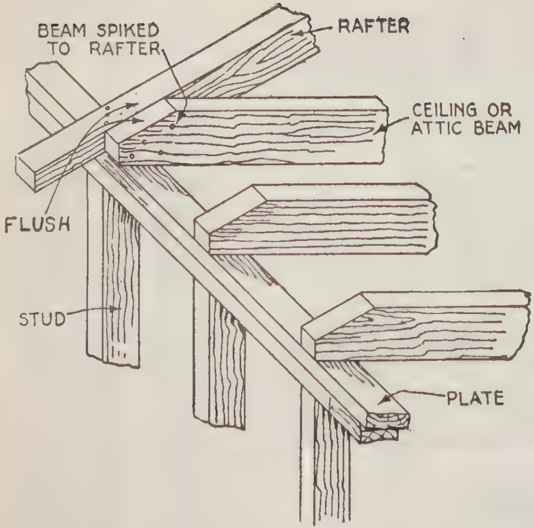
The wall plate which is the same length as sill, will plumb the second post one way after the first one has been plumbed, this time from the second floor and again the third tier of beams will line the walls.

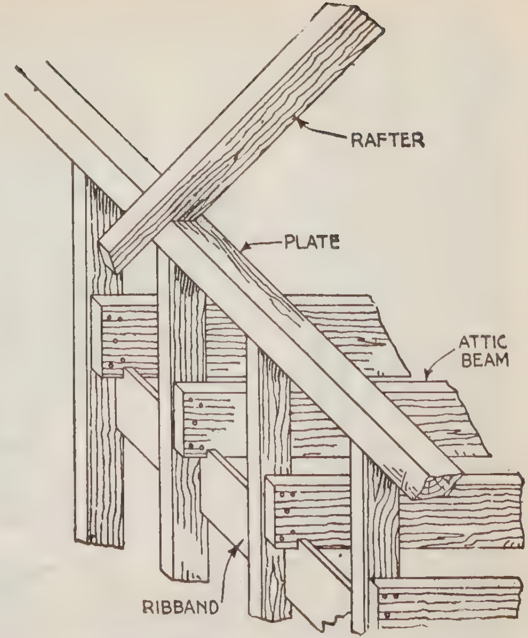


FIGS. 1,878 and 1,881.—Plate construction. Fig. 1,878, solid plate showing lap joint at post; fig. 1,881, built-up construction. Usually built-up plates are formed of 2 × 4, or 2 × 6 scantling in two thicknesses as shown. They are firmly joined at corners by overlapping and on long sides of building the joints are well broken to give extra strength.

If the second (third or fourth), story be not a full story, then the trussed rafters must hold the sides in place.

The ceiling beams usually rest on ribbands but sometimes on the plate, the ends being sawed at the angle of the rafters so they will not project above the rafters.





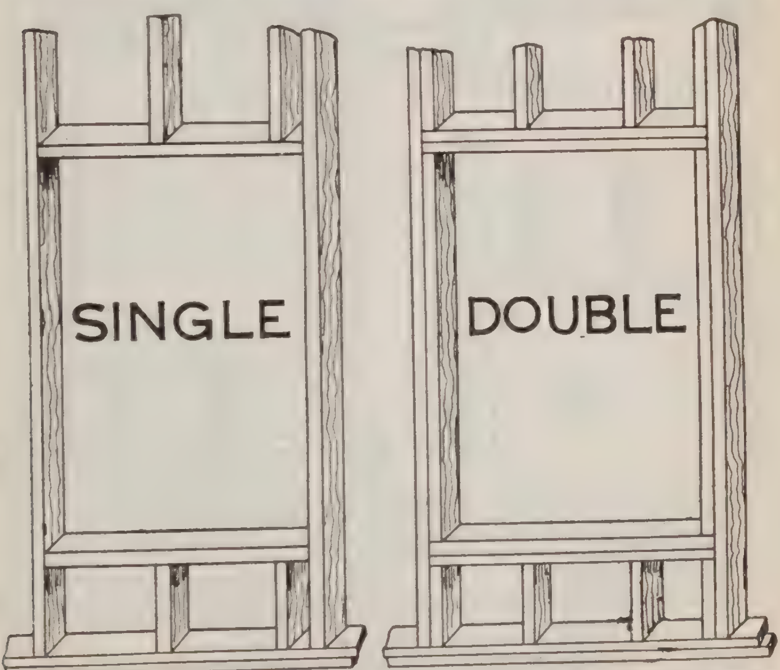
FIGS. 1,882 and 1,883.—Detail of plate showing method of supporting ceiling or attic beams on plate as in fig. 1,882, and on ribbands, as in fig. 1,883. Evidently the latter method is used where more head room is desired in the attic. The object of the plate is to tie the studding together at the top and furnish a support for the rafters and sometimes for the ceiling or attic floor beams, though the latter are usually supported by ribbands. The plate is spiked to the studding and corner posts, there being lap joint sat corners where two adjacent walls meet. ***In full frame work*** a solid 4 × 6 is generally used, and for balloon framing two 2 × 4 or 2 × 6 pieces placed one on top of the other, and breaking joints. The 4 inch or 6 inch under side is laid out or spaced for each stud to correspond with the sill below, so studs will be plumb. Some carpenters space them with a two foot rule as they are being nailed. but this method is likely to result in errors.

CHAPTER 41

Openings and Partitions

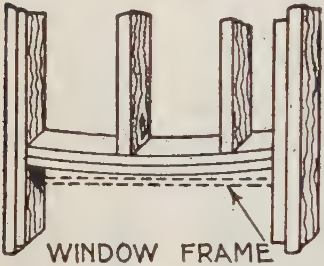
1. Openings

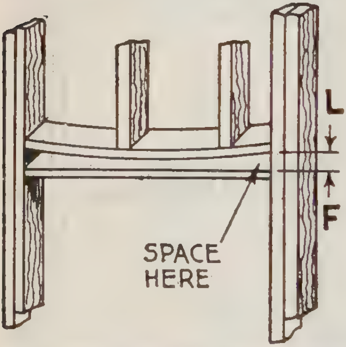
There are several wrong ways and one right way to frame the openings for windows and doors. Some set up all the

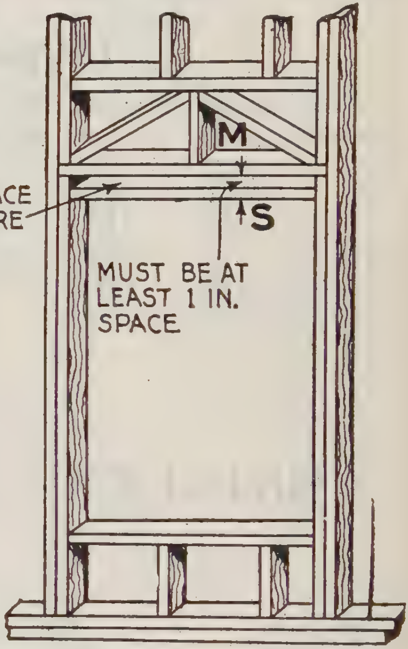


FIGS. 1,884 and 1,885.—Single and double framed openings for windows. All windows opening except those of very small size, should have double thickness of studding, but the arrangement of double studding shown in fig. 1,885 is objectionable, especially in balloon frames.

studding, and then cut the studs for the openings; others even put on the sheathing solid, cutting away both studs and sheathing for the openings. This is a waste of time and material. It is much easier to saw studs lying level on horses than when



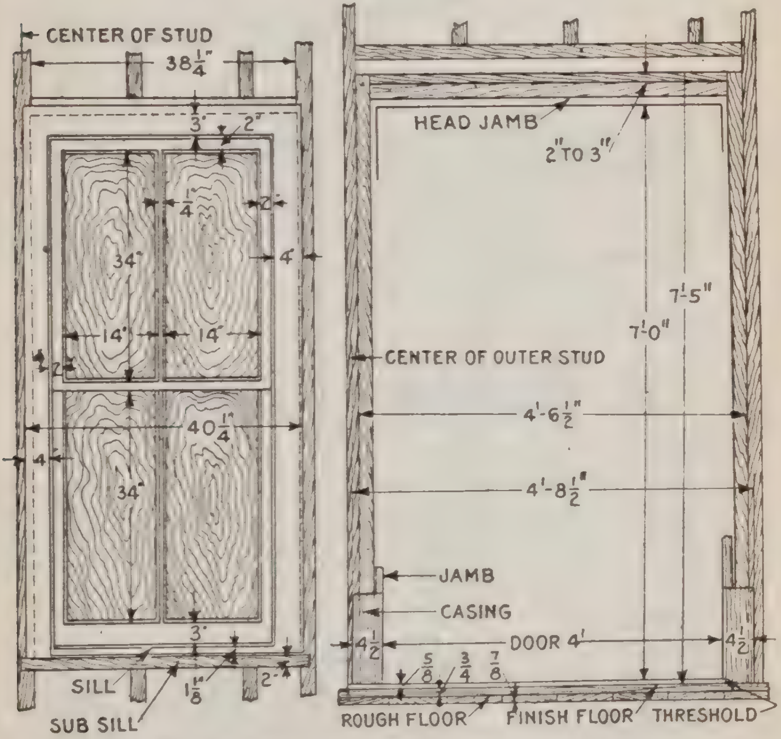




FIGS. 1,886 and 1,887.—Wrong and right way to construct header for window opening. In fig. 1,886 the weight carried by the studs is supported by both pieces forming the header. Now in a balloon frame, especially if there be no window directly above, considerable weight must be carried by the header, which will cause it to sag and the pressure will come on the window frame, distorting or injuring it. Fig. 1,887 shows how this may be avoided by leaving a space between the two pieces and arranging them so that all the load will be carried by the upper piece. The space LF, between cross pieces should be from 1 to 2 ins., depending upon span and load to be carried.

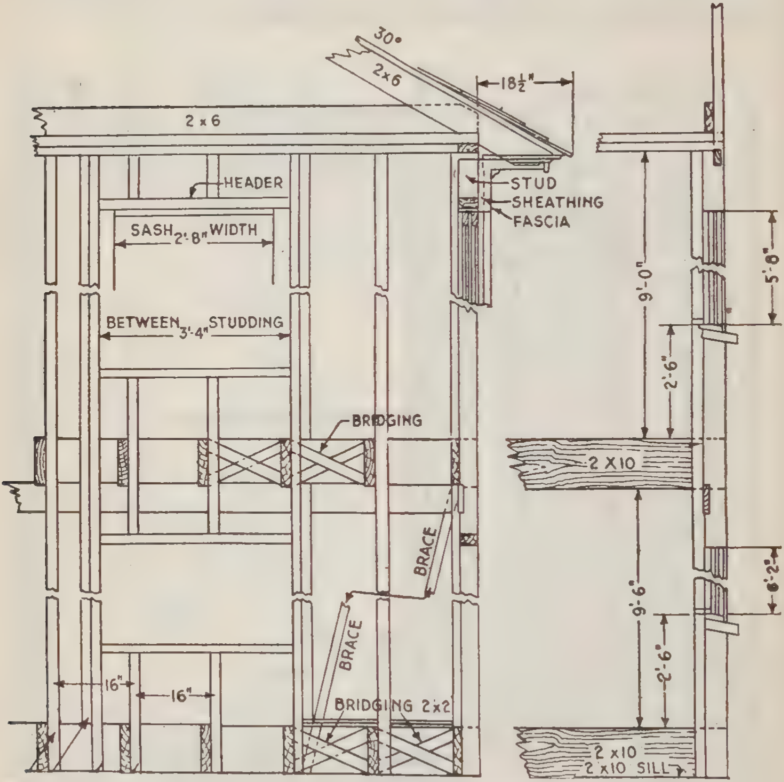
FIG. 1,888.—Truss over window opening, especially desirable in balloon frames where the studs extend from sill to plate and where considerable load must be carried. The two studs or diagonal pieces receive any load coming over the window and carry it to either side of the opening where it is taken by the side studs and carried down to the sill. The space between M, and S, must be at least one inch.

nailed upright in the frame. The openings should be laid out and framed complete before they are fastened to the frame. Studding at all openings must be double to furnish best and proper nailing for trim, and must be plumb.



FIGS. 1,889 and 1,890.—How to determine size of opening for a window. With dimensions given, ***vertical opening*** is estimated thus: sill 1⅛; sub sill, where frame is made with one, 2; bottom rail from edge to bottom of rabbet, 3; glass in lower sash, 34; meeting rail from rabbet to rabbet, 1; glass in upper sash, 34; top rail 2; space for head jamb and lugs of side jamb, 2 or 3; total, 79 ins. ***Carpenter's rule:*** Add 11 ins. to the glass measurement to get vertical height between stool and header. If there be any horizontal members add ¼ in. for each. ***Width:*** glass 28; munter ¼; stiles for rabbeted edge to outer edge 4; casings 8; total 40¼ ins. This is the distance from center of outer studs.

Some carpenters find it difficult to determine the proper sizes for the openings. Windows are usually listed by the size of the glass: thus, 24 × 32, two light means that the window has two lights with glass 24 inches wide



FIGS. 1,891 and 1,892.—Detail of two story house frame showing openings for windows.

NOTE.—How to estimate opening for door. ***Height:*** Allow rough floor ¾; finish floor *W*; threshold ⅝; door, 7, or as ordered; head jamb and space for lugs of side jambs 2 to 3; total from floor joist 7 ft. 5 ins. ***Width:*** Door 3 ft.; casings 4½ ft. each; total spacing center to center of studs 3 ft. 9 ins. This will leave space enough to put the doubling studs on each side between header and floor.

and 32 inches high. The width of the opening between studding should be 10 inches wider than the width of the glass which, in this case is 34 inches between studs. The height should be 11 inches more than the length of the two lights, thus two 32 inch lights measure 64 inches, and adding 11 inches, gives 75 inches. The 11 inch allowance is obtained thus: allow 6 inches for wood or sash in height, 2 inches top rail, 1 inch meeting rail, 3 inches for bottom rail, 1 inch for top jamb, 1 inch for sub sill, 2 inches for sill and 1 inch for play, making a total of 11 inches. Allow for possible variation from standard dimensions.

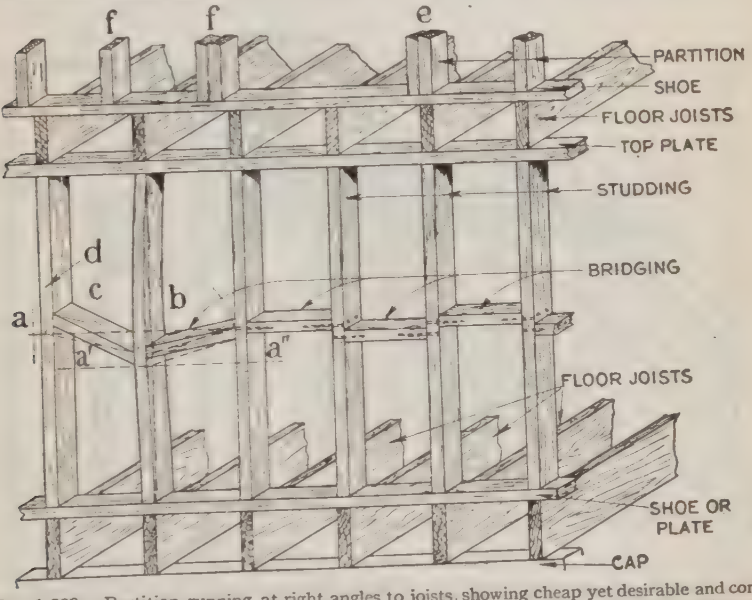


FIG. 1,893.—Partition running at right angles to joists, showing cheap yet desirable and common practice of stiffening with horizontal bridging cut from over lengths of studding set about midway between floor and ceiling. By inserting horizontal bridging, uniform spacing is readily secured. Assuming that lines have been struck on a level across the studs as *a a*, and that all cutting or bridging is cut to exact lengths, either for herringbone or linear; there is enough variation at times in the thickness of studs to distort their plumb line. When herringbone is used there is a tendency also to wedge when driving in and if care be not used in keeping to the line, allowing for variation, conditions as at *b* and *c* will occur. By it a percentage of support is lost and setting lath is affected. The curvature caused at *b*; sends *c*, much above the line. To drive it down would cause a greater spring in stud *d*. the level of floor above it is also affected. When shoe or plate is thin and laid directly across joists without sub-flooring under, care should be taken to—as near as possible—have studs rest on shoe directly over joists as at *e*, rather than as at *f*.

Figs. 1,884 to 1,887, show methods employed in framing openings for windows.

The construction shown in fig. 1,884 should not be tolerated except for very small windows. Fig. 1,885 shows the usual construction, which is not much better as explained in fig. 1,886. A first class truss arrangement is shown in fig. 1,887 which should be used in balloon frames especially where there is no window directly above on second story.

Usually windows are the same height as doors so that the measurement

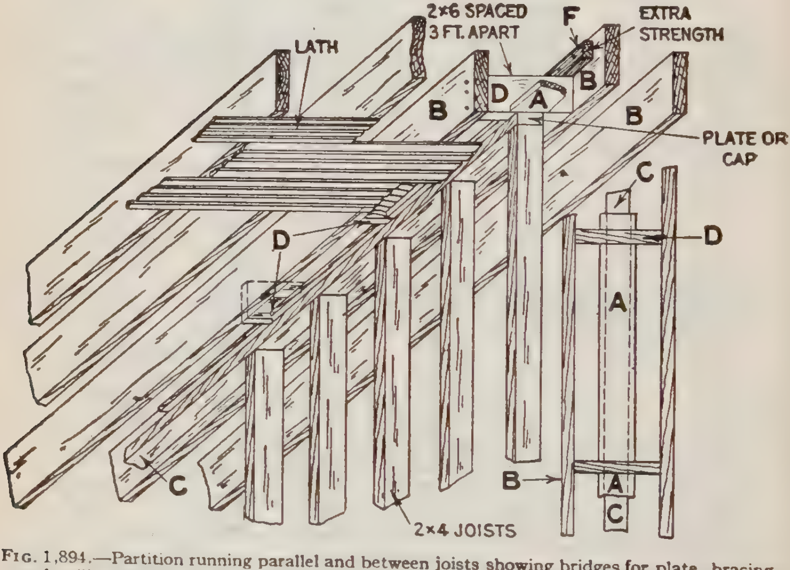


FIG. 1,894.—Partition running parallel and between joists showing bridges for plate, bracing, and nailing strip for laths.

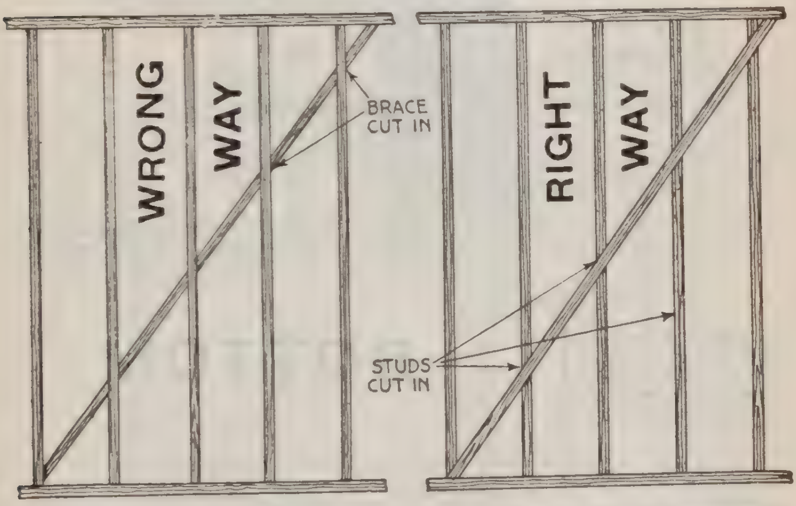
when obtained is right for many openings. Two inches on each side of a door is generally enough, that is, make the distance between studs 4 inches more than the door measurement; with the double studding cut in under the header, the outside studs should be set about 8 inches wider than the door.

Some carpenters make a "story pole" or dimension stick made from 1 × 2 or 1 × 3 stock with the heights of the openings from the rough floor or

from the joists where the rough floor is not laid, marked plainly thereon. This pole is placed alongside of the stud to be cut and the mark transcribed from pole to stud.

In general, carpenters plan to have the studs on either side of an opening either window or door, so set that the outer edges of the exterior casings will break upon their centers as shown in figs. 1,889 and 1890.

After the openings for the windows and doors are framed the structure may be sheathed, or the roof may be framed, both orders of proceeding with the work are common.



FIGS. 1,895 and 1,896.—Wrong and right way to brace a partition. When the brace is cut up into a number of pieces and fitted in between each stud, as in fig. 1,895, it is not nearly as effective in preventing the racking of the partition as when made in one piece and the stud scut in, as in fig. 1,896.

2. Partitions

The interior walls which divide the inside space of buildings into rooms, halls, etc., are known as partitions. These are made up of studding covered with lath and plaster, wall or compo board, metal lath and plaster and such like materials

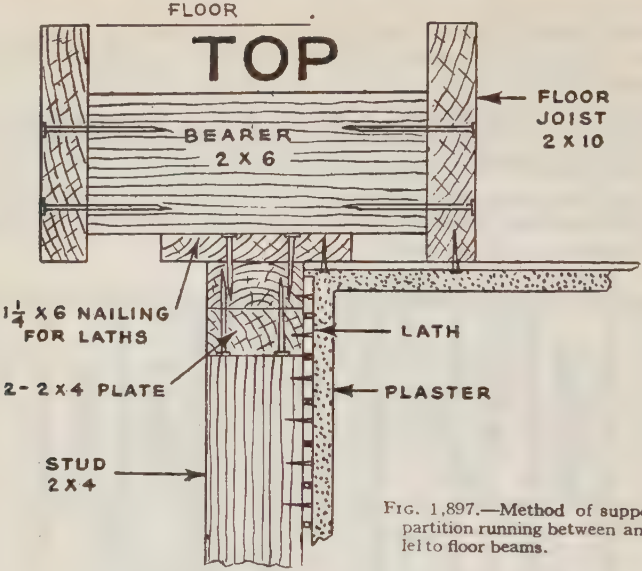


FIG. 1,897.—Method of supporting a partition running between and parallel to floor beams.

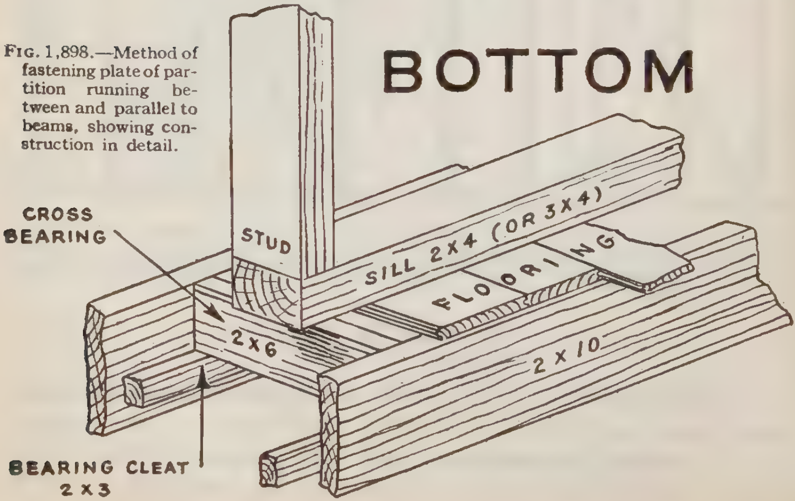


FIG. 1,898.—Method of fastening plate of partition running between and parallel to beams, showing construction in detail.

Fig. 1,893 shows the studding of an ordinary partition, each joist being 16 inches (on centers) away from the next or 16 inches from the inside face of one to the outside or further face of that next. So they are spaced 8, 12, 16 and 24 inches apart on centers as each plasterer's lath is 48 inches or 4 feet in length and the butt end joints of every lath will be placed in the middle of the face or edge of each stud or joist.

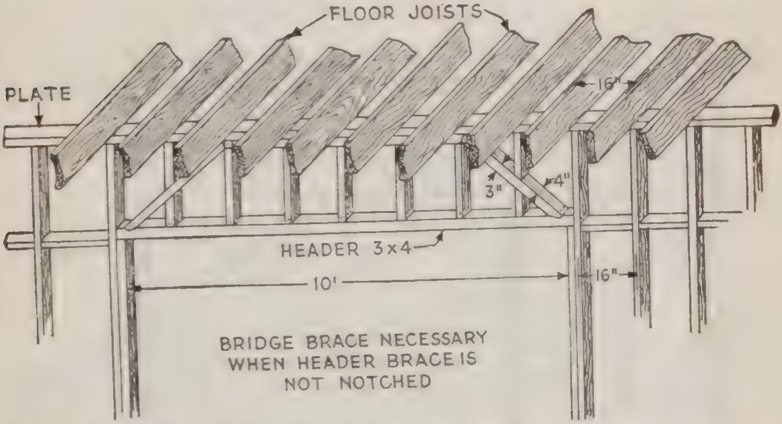


FIG. 1,899.—Opening in partition with braced header. Note that the braces are notched into header. This is important and prevents strain against stud in which case it could settle by shrinkage or possible pushing of stud unless prevented by a bridge brace as shown.

Where partitions are placed between and parallel to floor beams bridges must be placed between the beams to provide a means of fastening the partition plate as shown in fig. 1,897. The figure also shows angle piece for nailing lath and bracing.

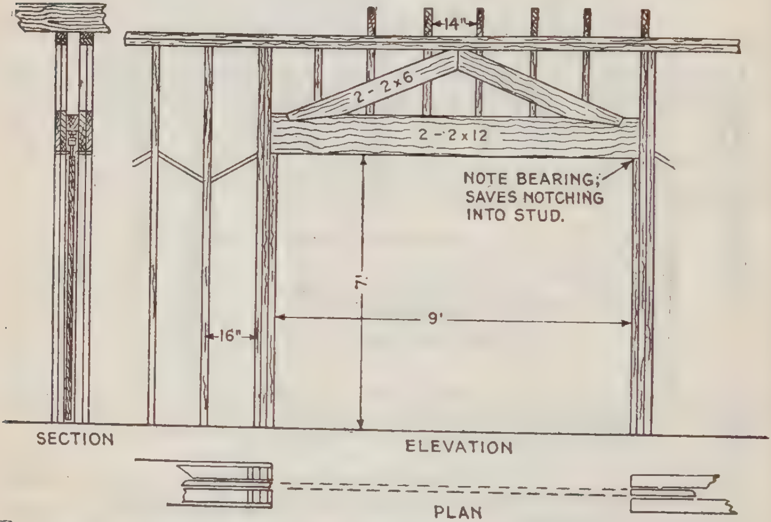
Figs. 1,895 and 1,896 show wrong and right way to brace a partition.

By putting in braces as in fig. 1,896 not only is their full strength obtained, but the frame of the partition can be

properly squared by measuring the diagonals and adjusting if necessary.

The arrangement in fig. 1,897 may be regarded simply as bridging and acts to stiffen rather than brace the frame.

Cross partitions in the center of the house should be braced in order to stiffen the side wall. When possible partitions



FIGS. 1,900 to 1,902.—Trussed partition construction for sliding doors.

should start upon a direct bearing from girder, or plate of partition below.

It is rarely now that single floors are laid thus when there

is an under or rough floor, the partitions are laid out upon it and a sill (shoe) 2 inches thick and the width of partition is laid securely nailed to the floor.

When, however, there is a considerable load coming on the partition and its base is between and parallel to floor beams, there should be 2 × 6 bridges cut across between them to prevent sagging, as shown in fig. 1,898.

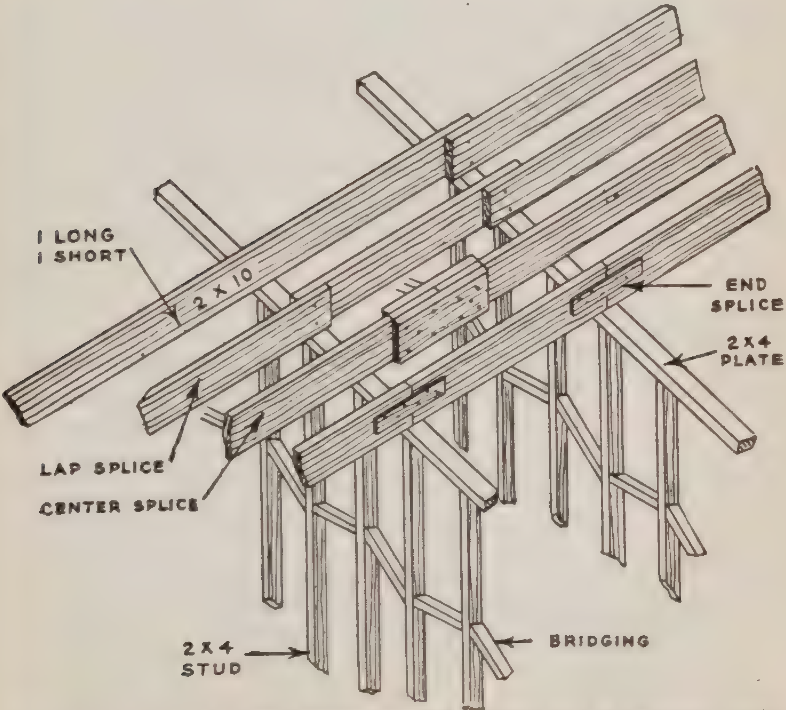


FIG. 1,903.—Double hall partitions showing how timbers (joists) may be lengthened, bearing upon them. The lapping method is best for all purposes, but when there is an under or rough first floor laid, butt end joints are just as good and are better for lathing.

The construction at the top is shown in fig. 1,897, which is a section of fig. 1,894. Where openings come in partitions over 30 inches between studs they must be trussed or braced. One method of doing this is shown in fig. 1,899.

CHAPTER 42

Roof Framing

As a preliminary to the study of this chapter the reader should review Chapter 4 in Vol. 1 on "How to Use the Steel Square." This tool which is invaluable to the carpenter in roof framing has been explained at great length in Chapter 7, with numerous examples in rafter cutting. Hence a knowledge of how to use the square will be assumed in this chapter to avoid repetition otherwise it would preclude fully presenting other important matter necessary for a complete treatment of the subject.

Types of Roof.—There are numerous forms of roof and an endless variety of shapes. The carpenter and student as well as the architect should be familiar with the names and features of the various forms. They are briefly.

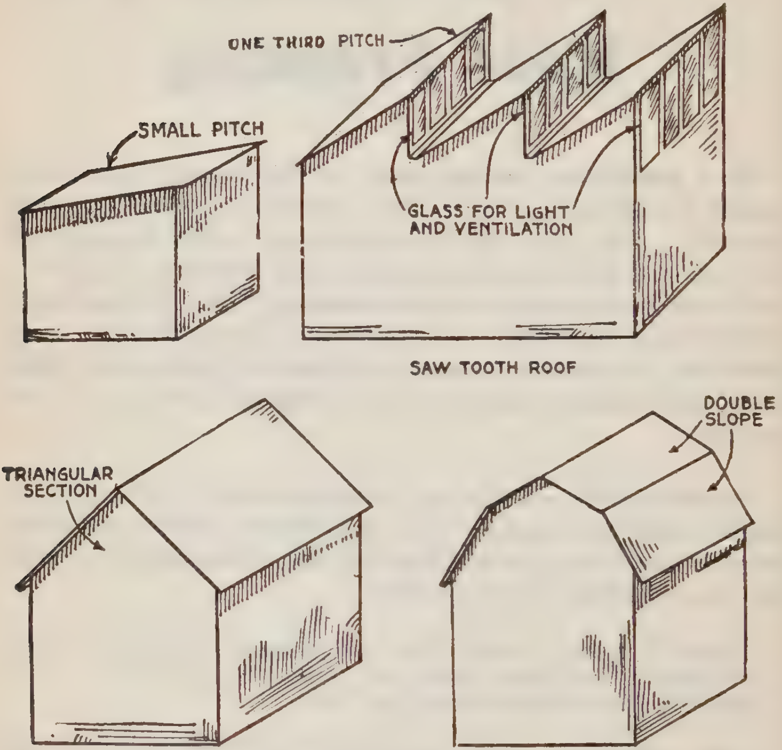
Shed or Lean to Roof.—This is the simplest form and is usually employed for small sheds, piazzas, out houses, etc. *It has* only a single slope and is not a thing of beauty; fig. 1,904.

Saw tooth Roof.—This is a development of the shed or lean-to roof, being virtually a series of lean to roofs covering one building, as in fig. 1,905. It is used on factories principally because of the extra light which may be obtained through windows on the vertical sides thus formed.

Gable or Pitch Roof.—This is a very common, simple and efficient form of roof and is used extensively on farms and small houses. It is oı triangular section, having two slopes, meeting at the center or *ridge* and

forming a *gable*, as in fig. 1,906. It is popular on account of the ease of construction and economy.

Gambrel Roof.—This is a modification of the gable roof, each side having two slopes, as shown in fig. 1,907.



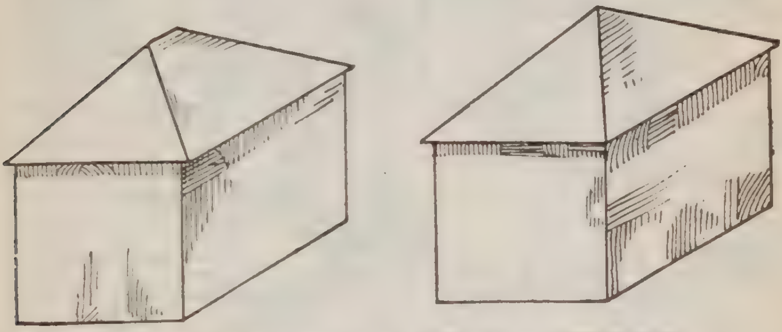
FIGS. 1,904 to 1,907.—***Various roofs, 1:*** Fig. 1,904, shed or lean to; fig. 1,905, saw tooth; fig. 1,906, gable or pitch (sometimes called saddle); fig. 1,907 gambrel.

Hip Roof.—It is formed of four straight sides all sloping toward the center of the building, terminating in a ridge, as in fig. 1,908, instead of a deck.

Pyramid Roof.—A modification of the hip roof in which the four straight

sides sloping toward the center terminate in a point as in fig. 1,909 instead of a ridge.

Hip and Valley Roof.—This is a combination of a hip roof and an intersecting gable roof covering a T or L shaped building, as in fig. 1,910, so called because hip and valley rafters are required in its construction. There are many modifications of this roof. Usually the intersection is at right angles, but need not be; either ridge may rise above the other and the pitches may be equal or different, thus giving rise to an endless variety, as indicated in figs. 1,910.



FIGS. 1,908 and 1,909.—***Various roofs, 2:*** fig. 1,908, hip; fig. 1,909, pyramid.

Double Gable Roof.—This is a modification of a gable or a hip and valley roof, in which the extension has two gables forming at its end an M-shape section, as in fig. 1,914.

Ogee Roof.—A pyramidal form of roof having steep sides sloping to the center, each side being ogee-shaped, that is, lying in a compound hollow and round curve, as in fig. 1,915.

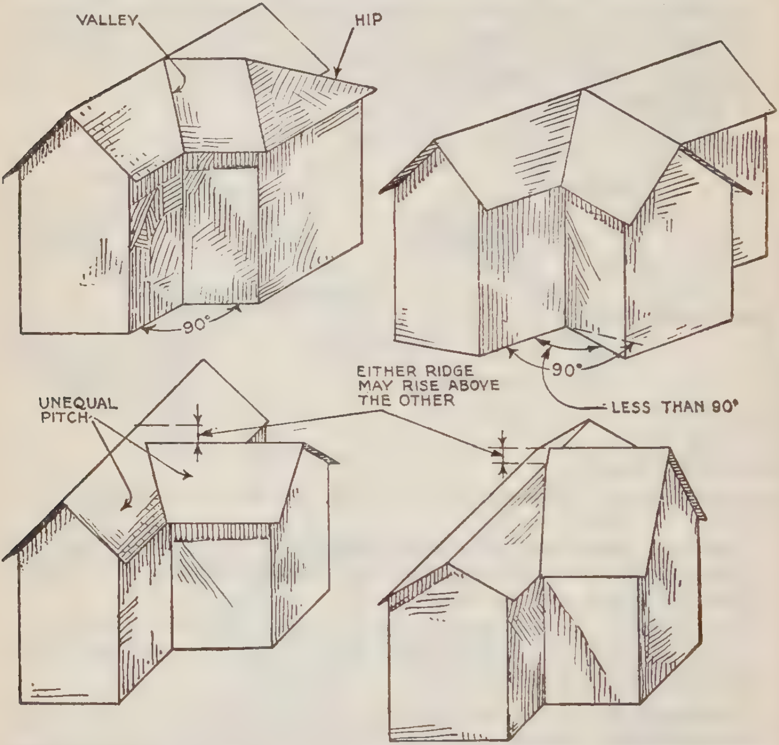
Mansard Roof.—The straight sides of this roof slope very steeply from each side of the building toward the center and the roof has a nearly flat deck on top, as in fig. 1,916. It was introduced by the architect whose name it bears.

French or Concave Mansard Roof.—This is a modification of the Mansard roof, its sides being concave instead of straight, as in fig. 1,917.

Conical Roof or Spire.—A steep roof of circular section which tapers uniformly from a circular base to a central point. It is frequently used on towers of cottages as in fig. 1,918.

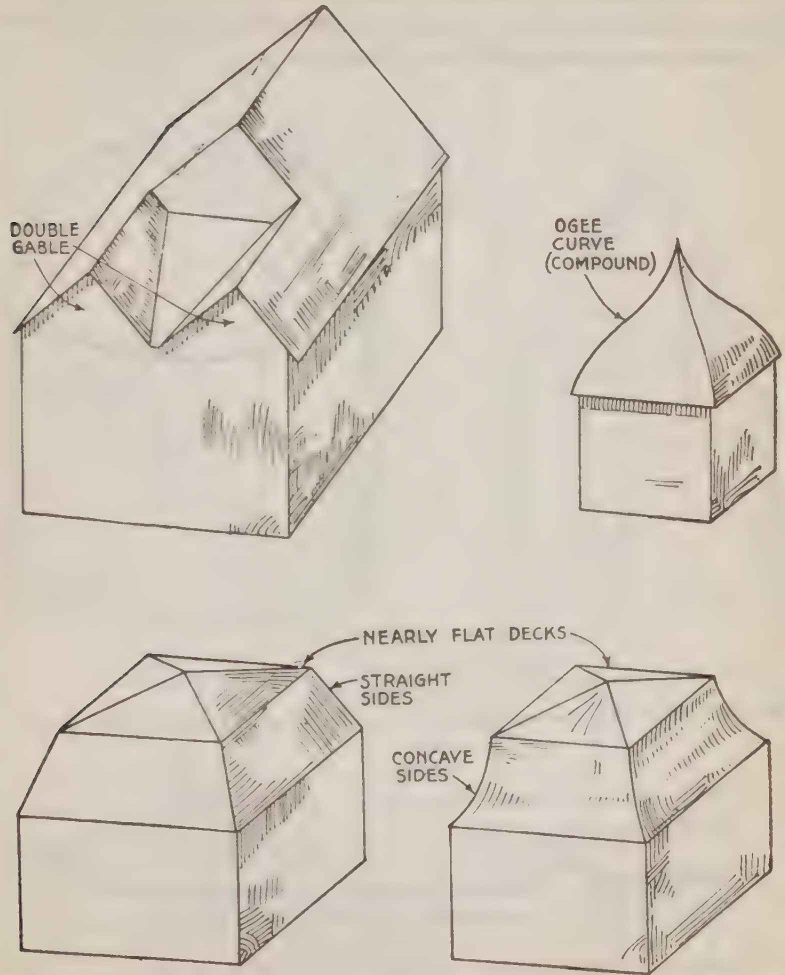
Dome.—A hemispherical form of roof as used chiefly on observatories, fig. 1,919.

Roof Construction.—The frame of any roof is made up of



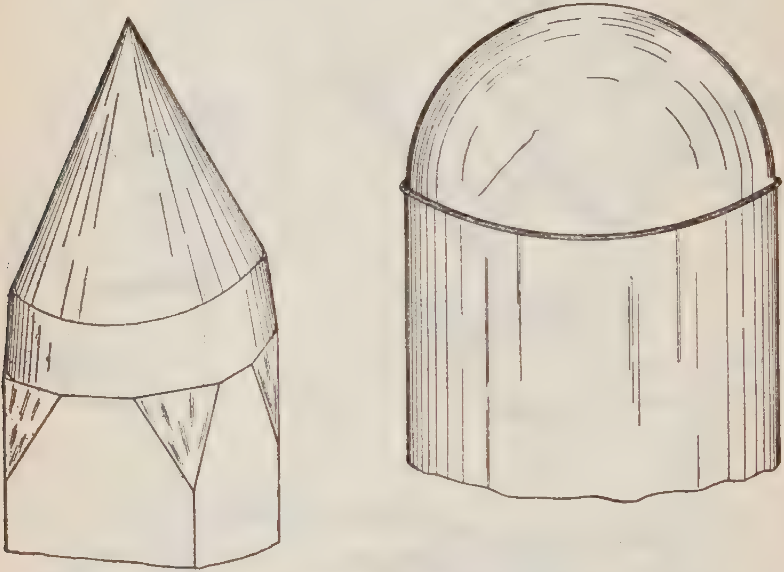
FIGS. 1,910 to 1,913.—*Various roofs, 3:* hip and valley with modifications; fig. 1,910, extension at right angles; fig. 1,911, extension at less than right angles; fig. 1,912, unequal pitch; fig. 1,913, unequal ridges.

numerous rectangular timbers called rafters. These are inclined upward in pairs, their lower ends resting on the plate, their upper ends being spiked together in cheap construction, or



FIGS. 1,914 to 1,917.—*Various roofs, 4:* fig. 1,914, double gable; fig. 1,915, ogee; fig. 1,916, Mansard; fig. 1,917, French.

to a ridge board in a properly constructed roof. On large buildings such frame work is usually reinforced by interior supports to avoid using abnormally large timbers.



FIGS. 1,918 and 1,919.—*Various roofs, 5:* Fig. 1,918 Conical or spire; fig. 1,919 dome.

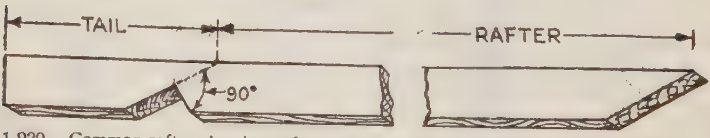
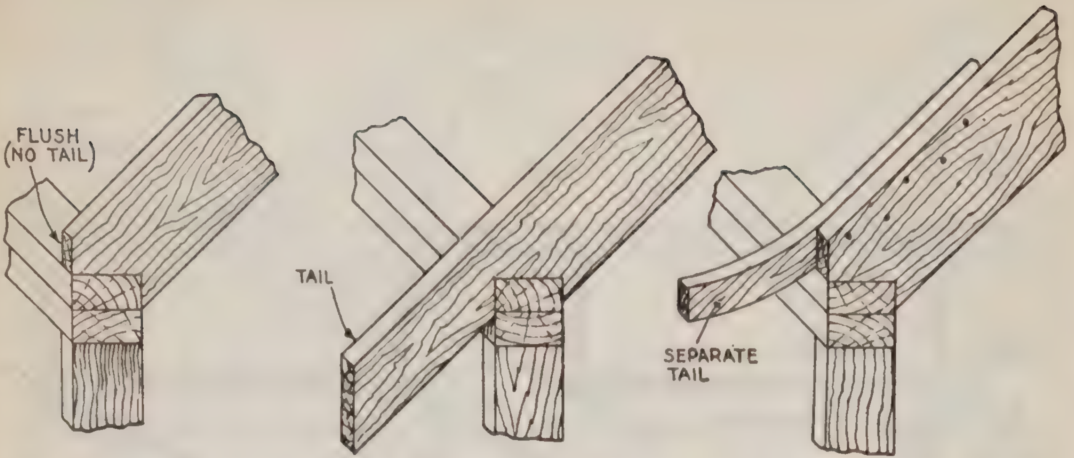


FIG. 1,920.—Common rafter showing rafter proper and tail, sometimes called look out.

Rafters.—These are the supports for the roof covering serving in the same capacity as joists for the floor or studs for the

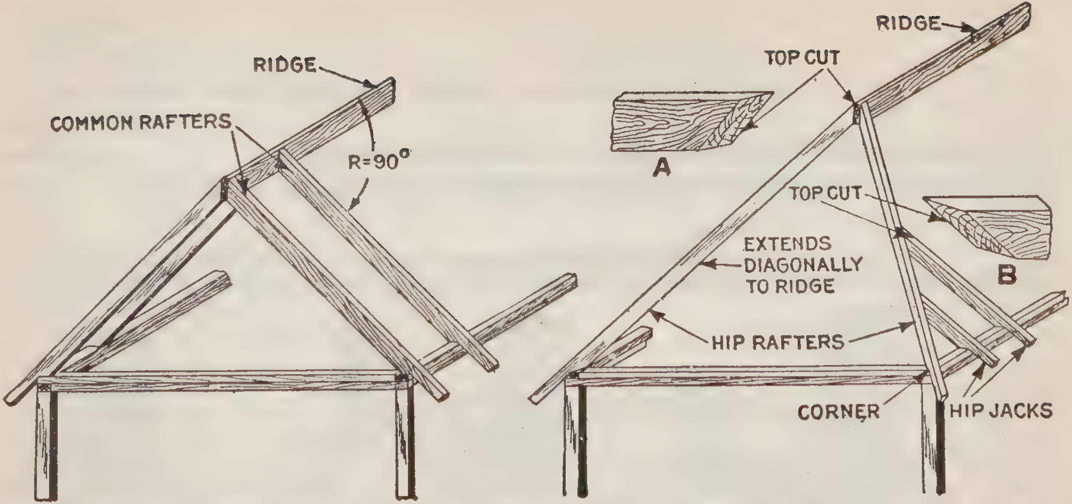


FIGS. 1,921 to 1,923.—Various forms of common rafter. Fig. 1,921, flush end without tail; fig. 1,922, tail or *look out* of reduced section integral with rafter; fig. 1,923, rafter with separate piece nailed on forming tail of curved design.

walls. According to the size of the building rafters vary in size from ordinary 2 × 4 studs to 2 × 10. For ordinary dwellings 2 × 8 rafters are used, spaced from 16 to 20 in. centers.

The various kinds of rafters used in roof construction are:

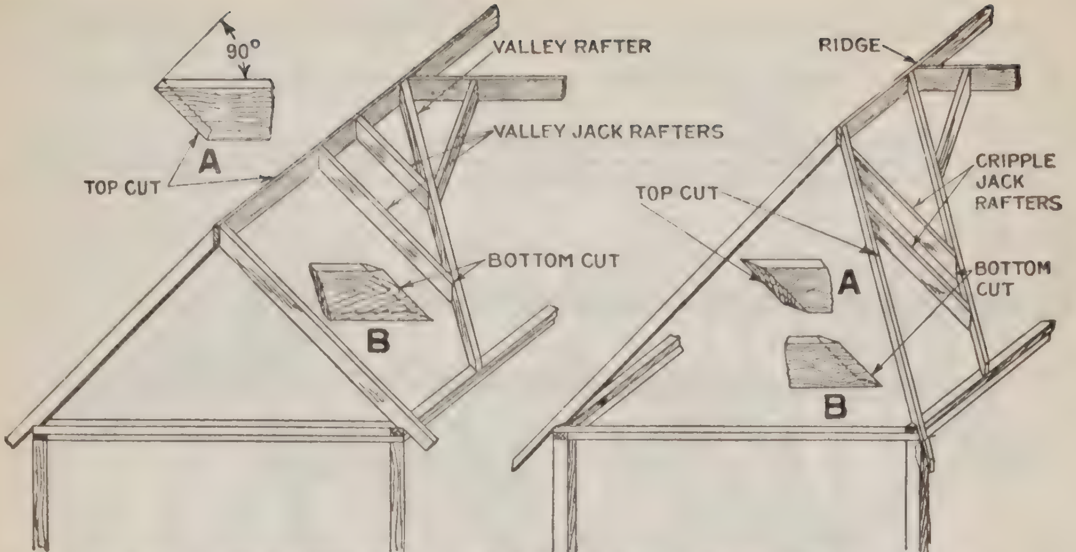
1, Common
2. Hip.



FIGS. 1,924 and 1,925.—***Various rafters, 1.*** Fig. 1,924, common rafters; fig. 1,925, two hip rafters extending from end corners of frame diagonally to ridge and two hip jack rafters extending from plate to hip rafters—note detail views showing top cuts A and B, of hip and jack respectively.

3. Valley.
4. Jack.

   a. Hip
   b. Valley
   c. Cripple



FIGS. 1,926 and 1,927.—***Various rafters, 2:*** Fig. 1,924, valley and valley jack rafters; fig. 1,927, cripple jack rafters. In the figures A, and B, show detail of top and bottom cuts as indicated by the arrows.

5. Octagon.

These various rafters are shown in figs. 1,924 to 1,927 and the carpenter should thoroughly note how to distinguish each kind as here briefly described:

Common Rafter.—A rafter extending at right angles from plate to ridge.

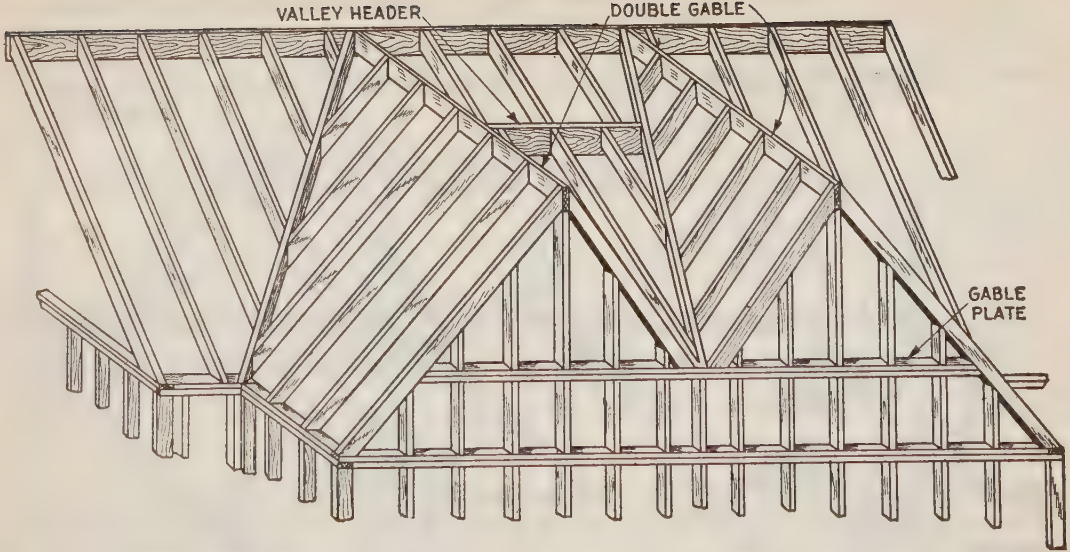


FIG. 1,928.—Consisting of double gable with valley between forming roof of an L extension. A second plate is used to support the two valley rafters between the two gables and end of valley H header being placed across the valley near the ridge so that extra rafters may be inserted between header and ridge to prevent the space becoming too great between rafters.

Hip Rafter.—A rafter extending diagonally from a corner of plate to ridge.

Valley Rafter.—A rafter extending diagonally from plate to ridge at the intersection of gable extension with main roof.

Jack Rafter.—Any rafter which does not extend from the plate to the ridge.

Hip Jack Rafter.—A rafter extending from plate to hip rafter at an angle of 90° to the plate.

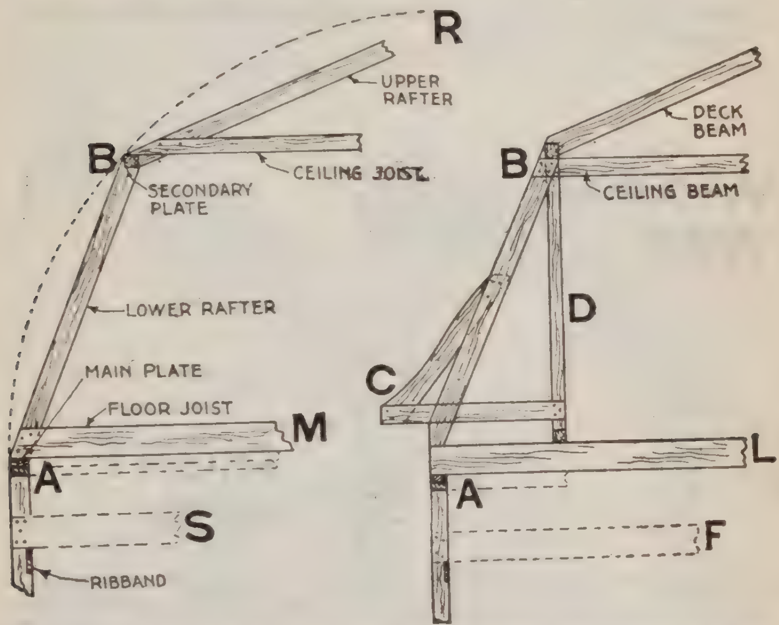


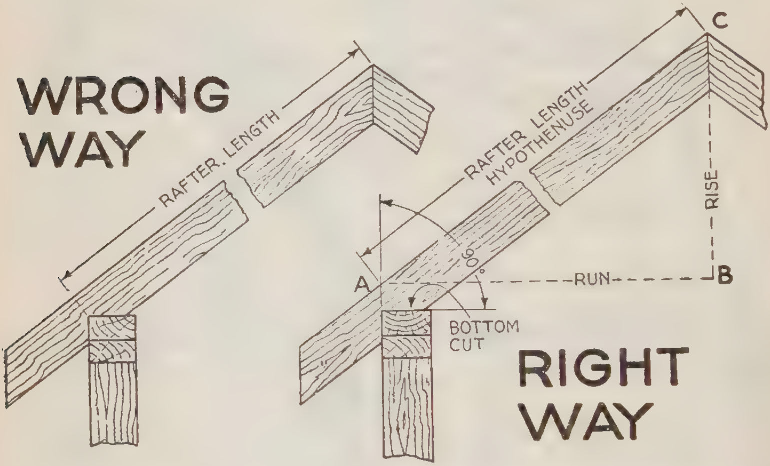
FIG. 1,929.—Construction of gambrel roof. The usual method is to frame the first slope between main plate A, and secondary plate, B, the secondary slope extending from B, to ridge. At B, the rafters are notched to make the joint shown the structure being reinforced by cross pieces which serve as ceiling joists. The floor joists may be either as placed at M, resting on the cap, or at S, resting on a ribband. When placed on the ribband the latter should not be located more than two or three feet below the plate. In either case the joists should be securely spiked to the rafters. A good proportion for the two slopes is obtained by locating the intersection of the two slopes in a circle R, whose diameter equals the span and with center in the plane of the main plate A.

FIG. 1,930.—Construction of French roof. It is framed in much the same way as is a gambrel roof. Rafters for the first slope (which is quite steep) are framed between the two plates A, and B. On plate B, rest the deck rafters which are very nearly horizontal. The curved form of the lower slope is obtained by piece C, which is nailed to the rafter, and to a horizontal member as shown. The vertical studding D, completes a trusswork which gives stiffness to the sides being tied together by the ceiling joists.

Valley Jack Rafter.—A rafter extending from valley rafter to ridge at an angle of 90° to the ridge.

Cripple Jack Rafter.—A rafter extending from valley rafter to hip rafter at an angle of 90° to the ridge.

Octagon Rafter.—Any rather extending from an octagon-shaped plate to a central apex, or ridge pole.



Figs. 1,931 and 1,932.—Wrong and right methods of measuring length of rafter. The length of a common rafter. It is not the distance from the outer edge of the plate to the apex (or top of ridge when there is one) but the hypothenuse of a right angle triangle whose sides are the *run* and *rise* as shown in dotted lines, fig. 1,933. After marking bottom cut, extend vertical side line to A; measure off AC, equal to the rafter length and in case there be a ridge board deduct half thickness of the ridge.

A rafter usually consists of a main part or rafter proper and a short length which extends beyond the plate, called the *tail*. The rafter and its tail may be all in one piece, or the tail may be a separate piece nailed on to the rafter. The tail may or may not continue in a straight line with the rafter.

Length of Rafter.—The length of a rafter may be found in several ways, as:

1. By calculation.
2. With steel square.

   a. Multi-position method
   b. By scaling
   c. By aid of framing table

Example.—What is the length of a common rafter having a run of 6 feet and rise of 4 inches per foot?

1. *By calculation*

With 6-foot run the total rise = 6 × 4 = 24 inches = 2 feet.

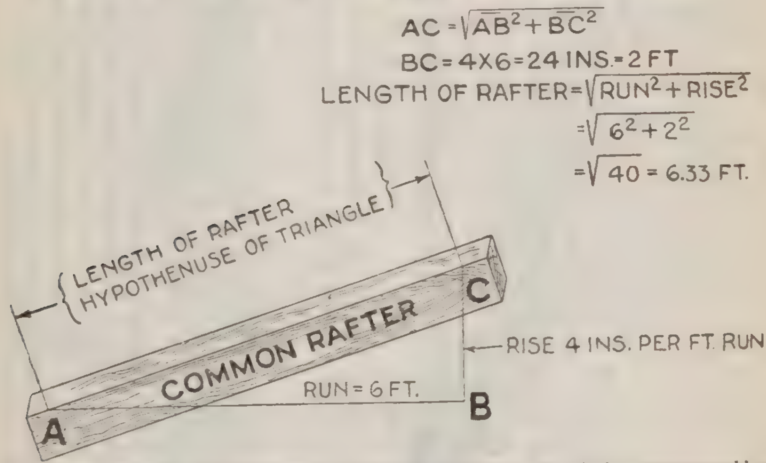


FIG. 1.933.—Method of finding length of rafter by calculation. Practical carpenters would not consider it economy to take time to find rafter lengths in this way because it takes too much time and there is chance of errors. It is to avoid both of these objections that the ***framing square*** (erroneously called steel square) has been developed.

Now since the edge of the rafter froms the hypothenuse of a right triangle whose other two sides are the run and rise, then length of rafter $= \sqrt{\text{run}^2 + \text{rise}^2} = \sqrt{6^2 + 2^2} = \sqrt{40} = 6.33$ feet, as illustrated in fig. 966.

2. *With steel square*

The so-called steel square reduces considerably the mental effort and chances of error in finding rafter lengths. The approved method of finding rafter lengths with the square is by aid of the fter table which was put on

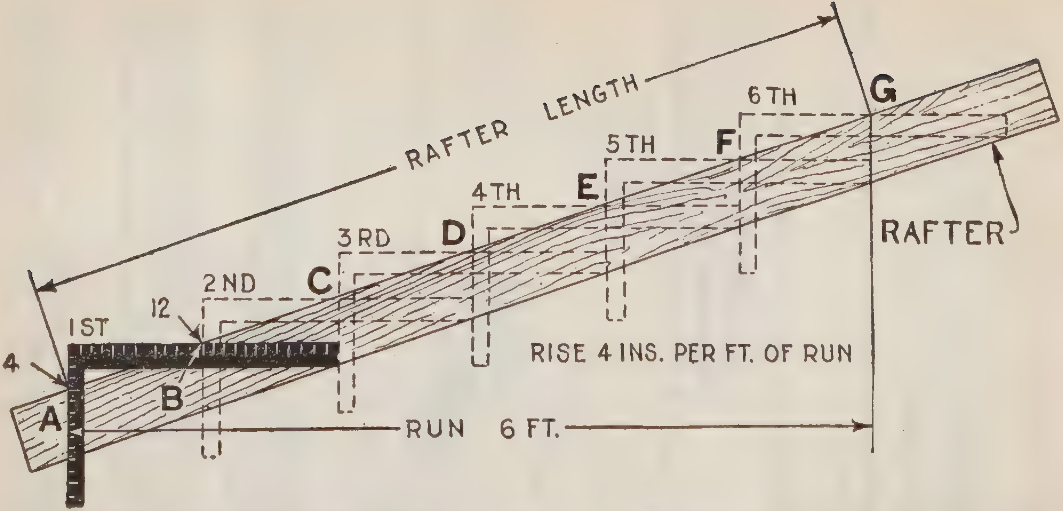
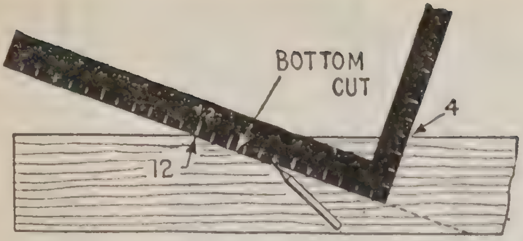
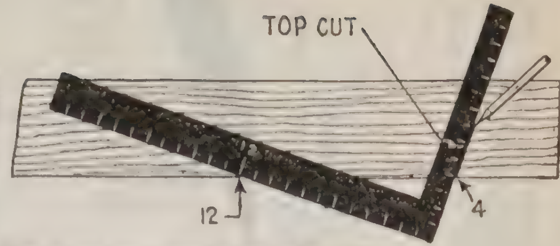


FIG. 1,934.—Multi-position method of finding rafter length. ***Problem:*** Lay off length of common rafter having a run of 6 ft. and rise of 4 ins. per ft. Locate a point A, on edge of rafter leaving enough stock for look out if any, and place steel square so that division 4, coincides with A, and 12, registering with edge at B. Evidently, if the run were 1 ft., distance AB, thus obtained would be the length of rafter; it is, in fact, the length of rafter *per foot run*. Hence, apply square six times for the 6 ft. run, obtaining points C, D, E, F, and G. AG, then, is length of rafter for given run.

the square for that purpose. However, some carpenters may possess a cheap square which does not have rafter tables. In such case the rafter length can be found either by the multi-position method shown in fig. 1,934, or by scaling as in figs. 1,938 to 1,940. In either of these methods the measurements should be made with extreme accuracy because in the multi-position method a separate measurement must be made for each foot run with chance for errors in each measurement, and in the scaling method any error made in scaling is multiplied by the number of feet in the run.





Figs. 1,935 and 1,936.—Bottom and top cuts for the common rafter whose length was obtained in fig. 1,938.

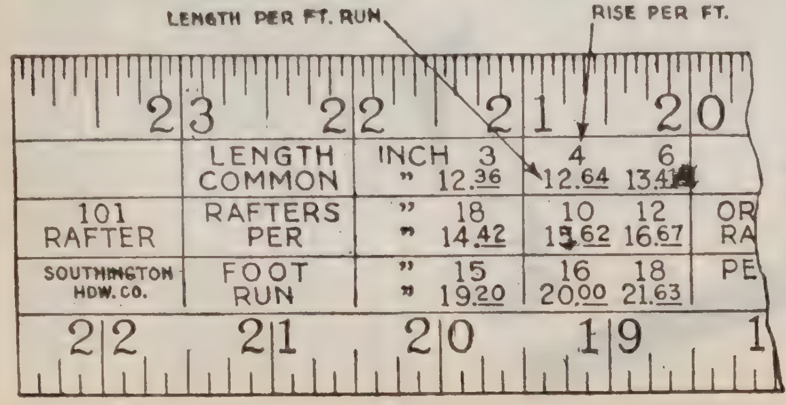


Fig. 1,937.—Method of finding rafter length by aid of Southington square framing table reading *length of rafter for given run*.

Figs. 1,937 and 1,941 show reading on rafter tables of two well-known makes of squares for length of rafter in preceding example, one giving length per foot run, and the other, the total length for the given run.

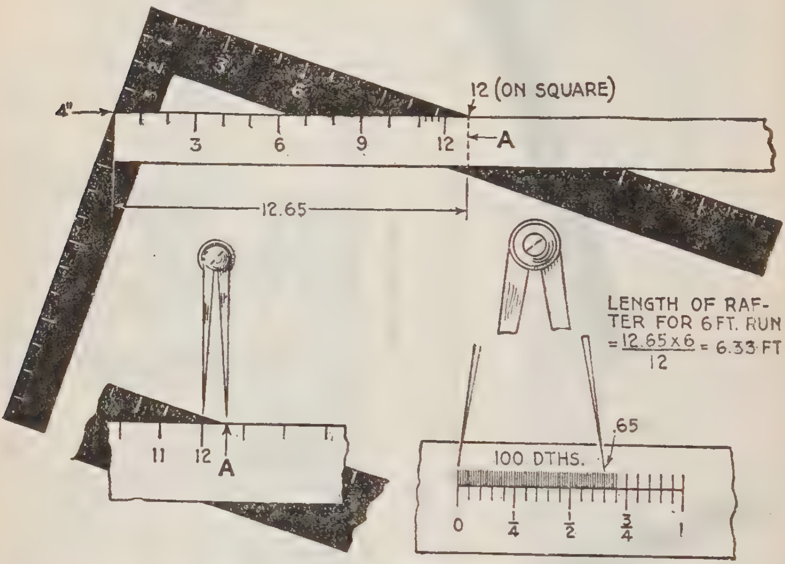


FIG. 1,938 to 1,940.—Method of finding rafter length by scaling. ***Case 1. Given rise per ft. in ins.*** Use two squares or a square and straight-edge scale, as shown. Place straight edge on square so as to read length of diagonal between rise of 4 ins. on tongue and 1 ft. or 12 ins. run on body as shown. The reading is a little over 12 ins. To find fraction, place dividers on 12 and point A, as in fig. 1,939, transfer to hundredths scale and read .65 as in fig. 1,940, making length of rafter 12.65 ins. per ft. run which for 6 ft. run = 12.65 × (6 ÷ 12) = 6.33 ft. ***Case 2. Total rise and run given in ft.*** Let each inch on tongue and body of square = 1 ft. The straight edge should be divided into ins. and 12ths so that on a scale of 1 in. = 1 ft. each division will = 1 in. Read the diagonal length between the numbers representing the run and rise (12 and 4), taking the whole number of ins. as ft., and the fractions as ins. Take off fraction with dividers and apply to 100th scale similarly as was done in case 1, figs. 1,939 and 1,940.

In estimating the total length of stock for a rafter having a tail, the run of tail or length of lookout must of course be considered. The pitches most generally used are ½, ⅓ and ¼, these corresponding to rises of 12, 8, and 6 inches per foot run respectively.

Rafter Cuts.—All rafters must be cut to the proper angle or bevel at the points where they are fastened and in the case of overhanging rafters also at the outer end. The various cuts are known as:

1. Top or plumb.
2. Bottom, or seat, or heel.
3. Tail or look out.
4. Side, or cheek.

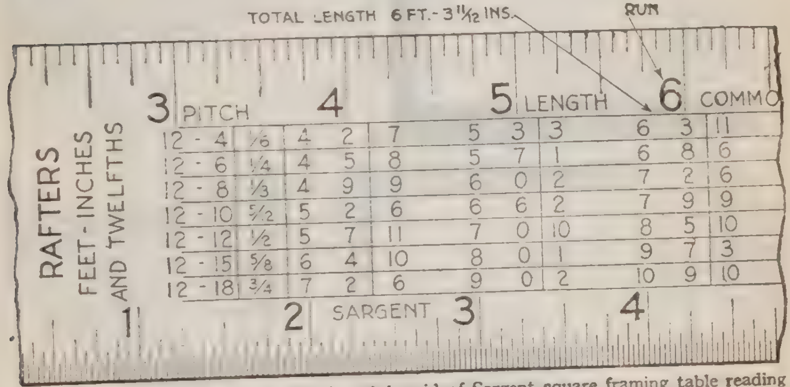
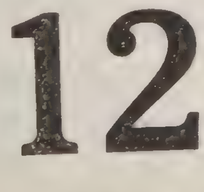


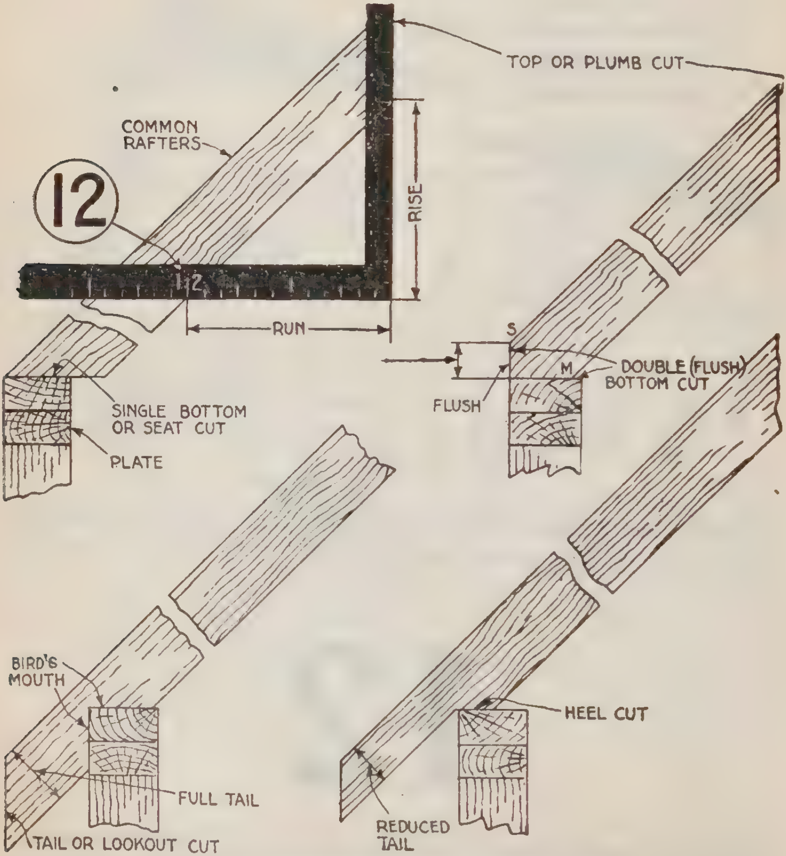
FIG. 1,941.—Method of finding rafter length by aid of Sargent square framing table reading *length of rafter per foot run.*



Common Rafter Cuts.—All the cuts for the various types of common rafters are made at right angles to the sides of the

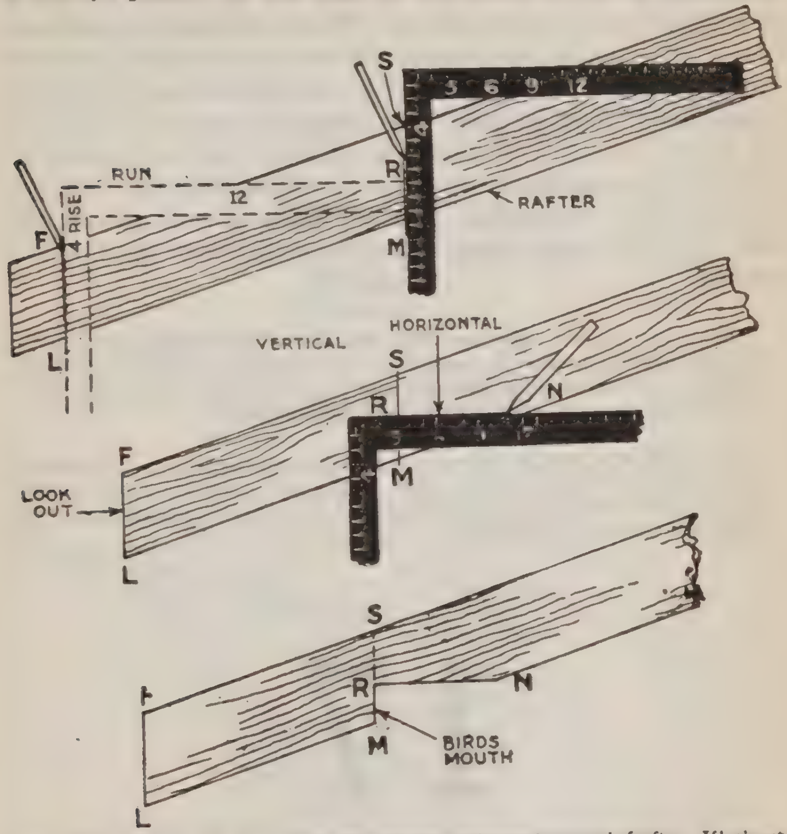
rafter, that is, not beveled as in the case of jacks, and are comparatively simple.

Figs. 1,942 to 1,945 show various common rafters from which the nature of these various cuts are seen.



FIGS. 1,942 to 1,945.—Various common rafters illustrating types and names of cuts; also, showing why one side of the square is set to 12. in laying out the cuts.

In laying out cuts for common rafters one side of the square is always placed on the edge of the stock at **12,** as distinctly



FIGS. 1,946 to 1,948.—Method of using the square in laying out lower end of rafter. If look out or tail cut is to be vertical, place square at end of stock with rise and run setting as shown (fig. 1,946) and scribe cut line LF. Lay off FS, equal to length of look out and move up square to S, with same setting scribing line MS. On this line lay off MR, length of vertical side of bottom cut. Now apply same setting to bottom edge of rafter so that edge of square cuts R, and scribe RN, which is the horizontal side line of the bottom cut. In making the bottom cut, the wood is cut out to the lines MR, and RN. The look out and bottom cuts are shown made in fig. 1,943, RN, being side which rests on the plate, and RM, side which touches the outer side of the plate.

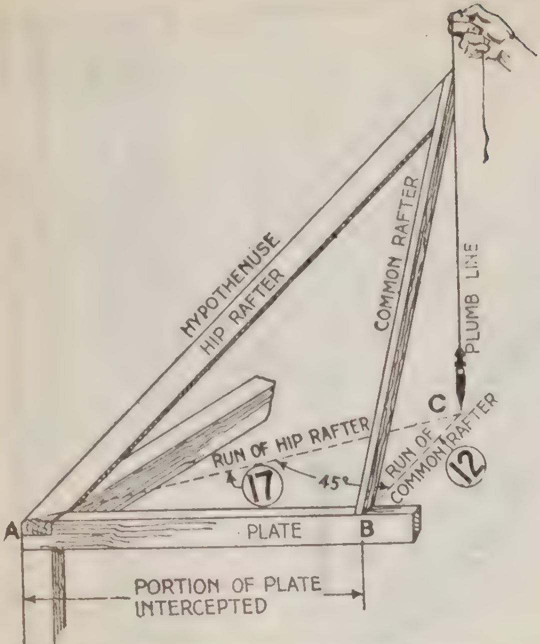
shown in fig. 1,942. This distance **12** corresponds for 1 ft. of the run; the other side of the square is set with the edge of the stock to the rise in inches *per foot run*. This is virtually a repetition of fig. 1,934, but it is very important to understand *why* one side of the square is set to **12** for common rafters—not simply to know that **12** must be used. On rafters having a full tail as in fig. 1,944, some carpenters allow cutting of the rafter tails to wait until the rafters are set in place so that they may be lined and cut while in position. Certain kinds of work permit the ends to be cut at the same time the remainder of the rafter is framed.

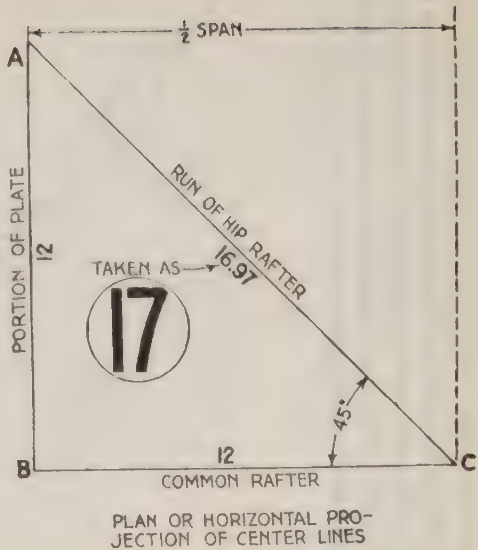
On rafters having tails there are two sides of the bottom cut, one M, horizontal and the other S, vertical, as on a lifted flush type of rafter (fig. 1,943), or a bird's mouth form of bottom cut, fig. 1,944. The name bird's mouth is given to the triangular section thus cut out.

The method of handling the square in laying out the bottom and look out cuts is shown in figs. 1,946 to 1,948. In laying out the top or plumb cut, if there be a ridge board, one-half of the thickness of the ridge must be deducted from rafter length.

17

Hip, and Valley Rafter Cuts.—The hip rafter *lies in the plane of the common rafters*, and forms *the hypothenuse of a triangle* of which one leg is the adjacent common rafter and the other leg, the portion of the plate intercepted between the feet of the hip and common rafters as in figs. 1,949 and 1,950.





FIGS. 1,949 and 1,950.—View of hip and common rafters in position, and diagram explaining "17." In fig. 1,949, take the run of the common rafter, as 12, which may be considered as 1 ft. (12 ins.) of the run or the total run of 12 ft. (= ½ span). Now for 12 ft. intercept on the plate (that is, the hip run inclined 45° to common run, as in the triangle ABC, $AC^2 = \sqrt{AB^2 + BC^2} = \sqrt{12^2 + 12^2} = 16.97$ or approximately **17**. Thus, the run of the hip rafter is to the run of the common rafter as **17** is to **12.** Accordingly, in laying out cuts use figure **17** on one side of square and the given rise in ins. per foot on the other side. This holds also for top and bottom cuts of valley rafters when plate intercept AB = run BC of common rafter.

The line of measurement for length of a hip and valley rafter is along the middle of the back or top edge, as on common and jack rafters. The rise is the same as that of a common rafter and the run of a hip rafter is the horizontal distance from the plumb line of its rise to the outside of the plate at the foot of the hip rafter.

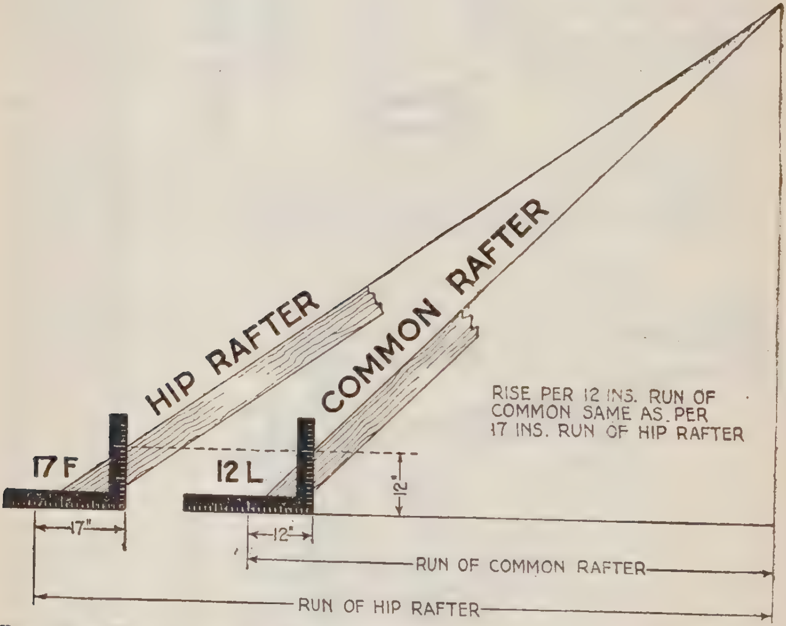
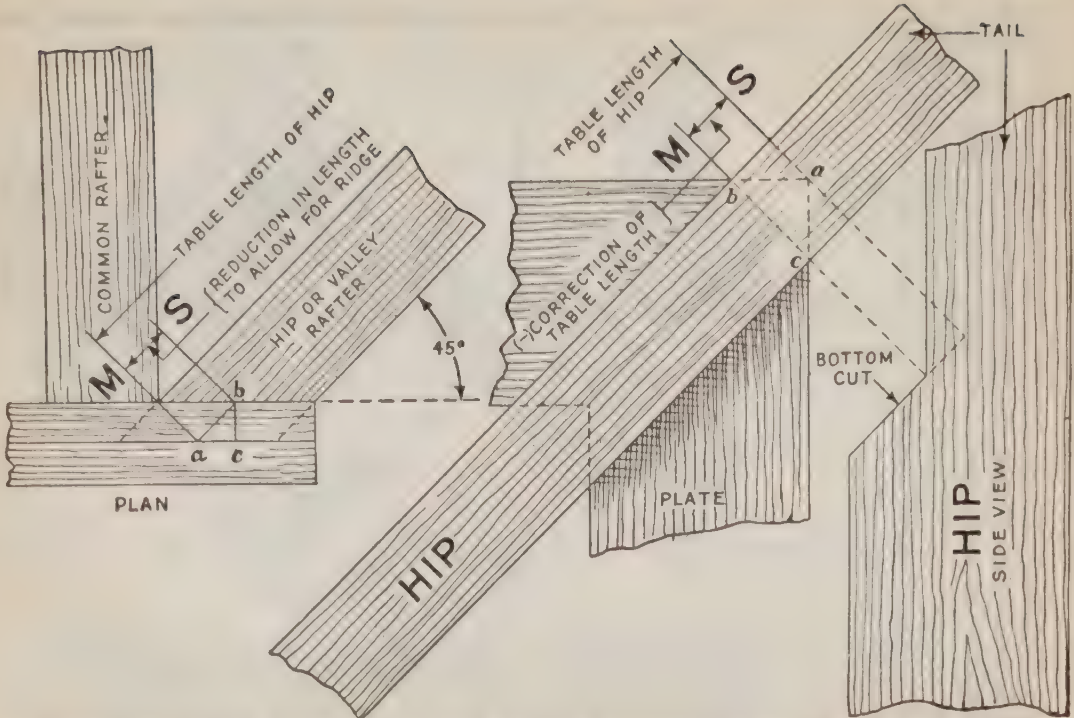


FIG. 1,951.—Hip and common rafters shown in the same plane illustrating the use of **17** in laying out the cuts. Evidently if the run of the hip rafter be to the run of the common rafter, as **17** is to **12**, then the rise due to **12** ins. run of the common rafter would be the same as that due to 17 ins. run of the hip rafter, *assuming the hip to be a "45° hip"*. The square at L and F, show 12 and 17 ins. runs for equal rise of common and 45° hip rafters respectively.

The run of a hip or valley rafter is to the run of the common rafter as 17 is to 12. Hence in applying the square for cuts of

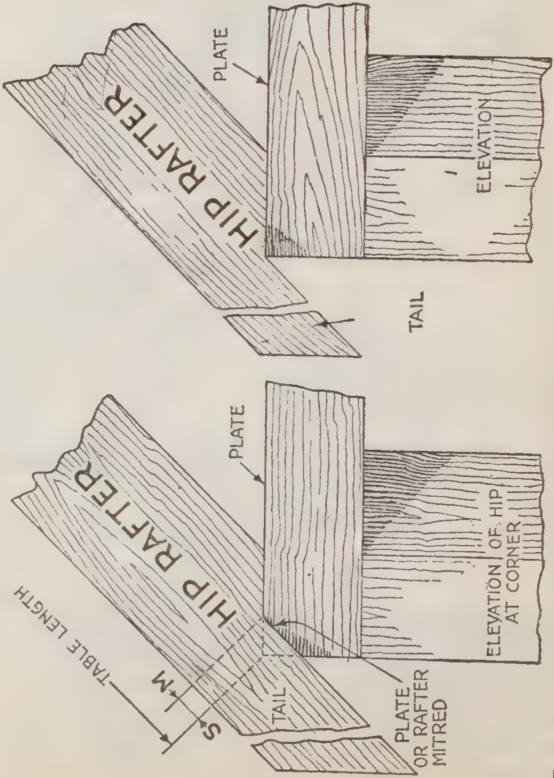


FIGS. 1,952 to 1,954.—Correction in table length for top cut to allow for half thickness of ridge board. The table length as read from the square must be reduced an amount equal to MS. This is equal to the hypothenuse *ab*, of the little triangle *abc*, which in value $= \sqrt{ac^2 + bc^2} = \sqrt{ac} \times$ half thickness of ridge^2. In ordinary practice take MS, as equal to half thickness of ridge. The

hip or valley rafters *use the distance* **17** *on the body of the square in the same way as* **12** *was used for common rafters*, when the plate distance between hip and common rafters is equal to half the span or run of the common rafter; that is, when the line of run of the hip lies at 45° to the line of run of the common rafter as indicated in fig. 1,949.

FIGS. 1,952 to 1,954.—*Continued.*

plan and side view of ***hip*** rafter shows table length, and correction MS, which must be *deducted* from table length so that sides of rafter at end of bottom cut will intersect outside edges of the plates. The table length of the hip rafter as read on the framing square will cover the span from the ridge to outside cover *a* of the plate, but the side edges of the hip intersect the plates at *b*, and *c*, hence the distance that *a*, projects beyond a line connecting *bc*, or MS, must be deducted, that is, measured backward toward the ridge end of the hip.



FIGS. 1,955 and 1,956.—Hip rafter with, and without correction MS, of table length.

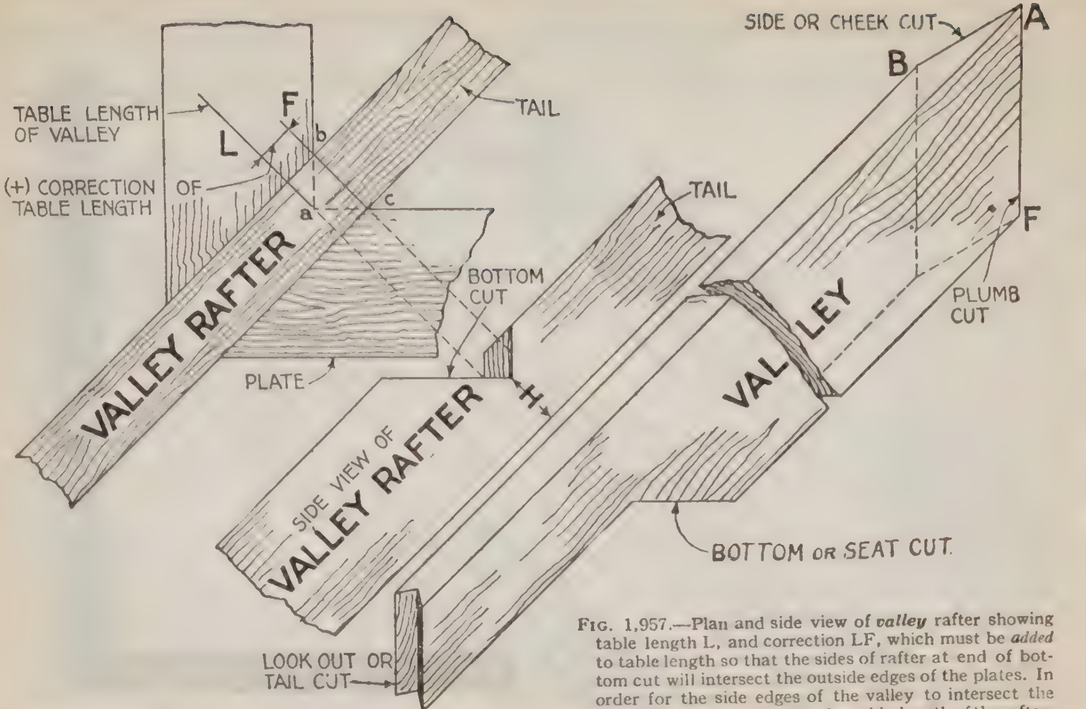


FIG. 1,957.—Plan and side view of *valley* rafter showing table length L, and correction LF, which must be *added* to table length so that the sides of rafter at end of bottom cut will intersect the outside edges of the plates. In order for the side edges of the valley to intersect the plates at *b*, and *c*, the distance that *a*, projects from the line joining *bc*, or LF, must be added to the table length of the rafter.

FIG. 1,958.—View of valley rafter showing all cuts. The method of obtaining side cut BAF, without aid of the framing square is explained in fig. 1,965. The lettering being the same. The method there given applies only to 45° hips or valleys.

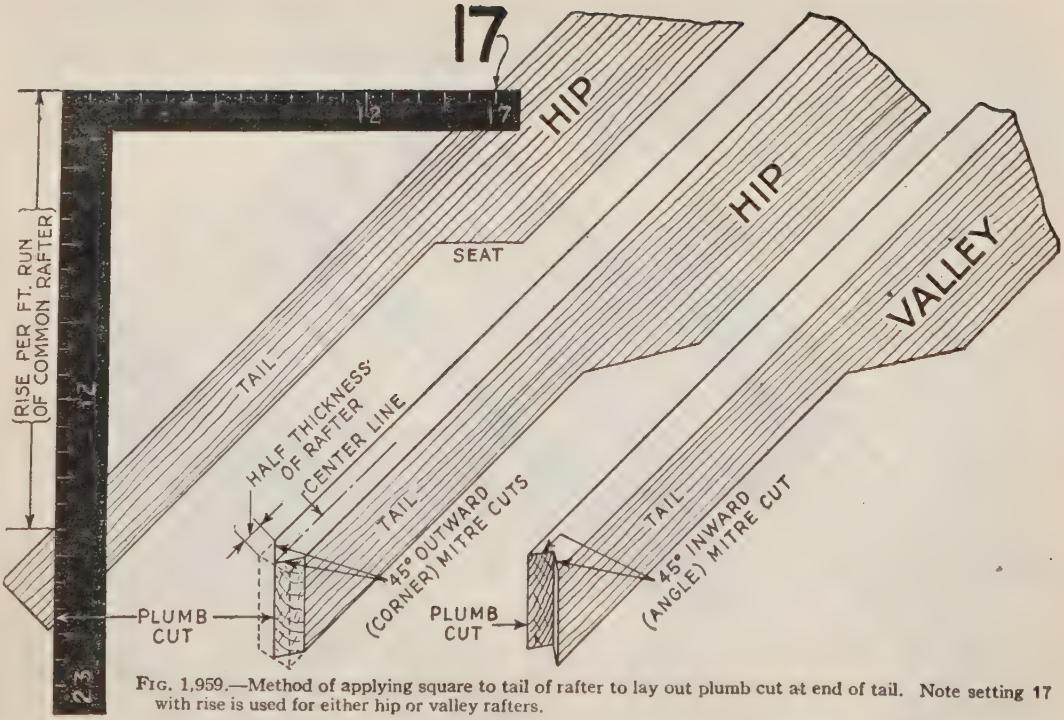


FIG. 1,959.—Method of applying square to tail of rafter to lay out plumb cut at end of tail. Note setting 17 with rise is used for either hip or valley rafters.

FIGS. 1,960 and 1,961.—Mitre cuts at end of hip and valley rafters so that the plumb faces will lie in plane parallel to the directions of the plates, giving correct bevels to receive fascia.

The length of a hip rafter as given in the framing table on the square is the distance from the ridge board to outer edge of plate. In practice deduct from this length one-half thickness of ridge board and add for any projection beyond the plate for eave. Fig. 1,952 shows correction for table length of hip rafter to allow for ridge and fig. 1,953 correction at the plate end which may or may not be made as in figs. 1,955 and 1,956. In making the bottom cut of a valley rafter it should be noted that a valley rafter differs from a hip in that correction distance for table length must be added instead

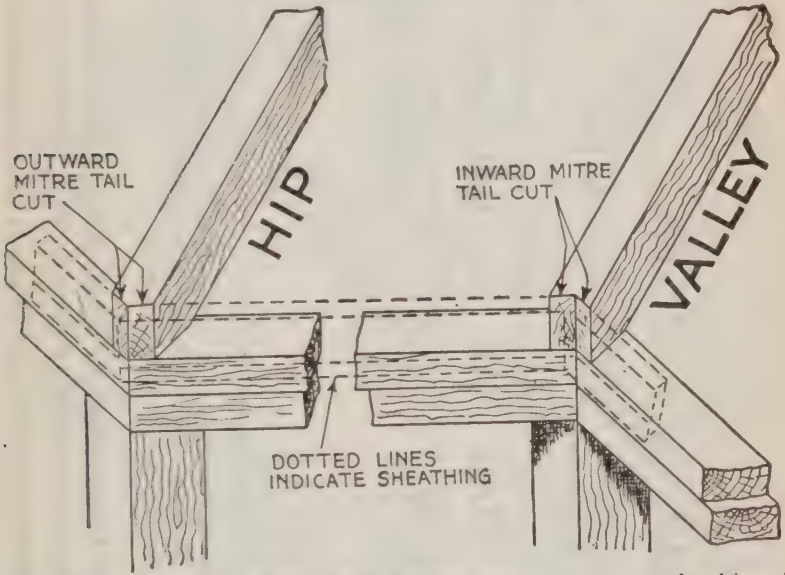
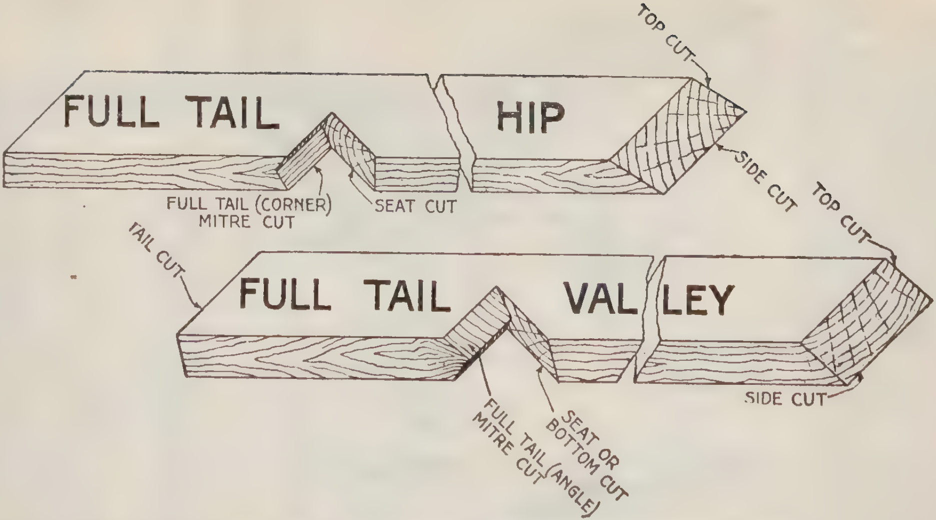


FIG. 1,962.—Flush hip and valley rafters in place on plate showing outward and inward mitre cuts. These cuts are made so that the end faces of rafter will lie flush or in planes parallel to outer sides of plates.

of subtracted as for hip rafter, that is, a distance MS, was subtracted from the table length of hip rafter in fig. 1,953 and an equal distance LF, was added for valley rafter in fig. 1,957, the reason being fully explained under the figures.

A further difference in hip and valley rafters is in the look out or tail cut. Usually the tail end of all rafters are cut plumb. Fig. 1,959 shows application of the square set to **17** for obtaining plumb cut on tail of hip rafter.

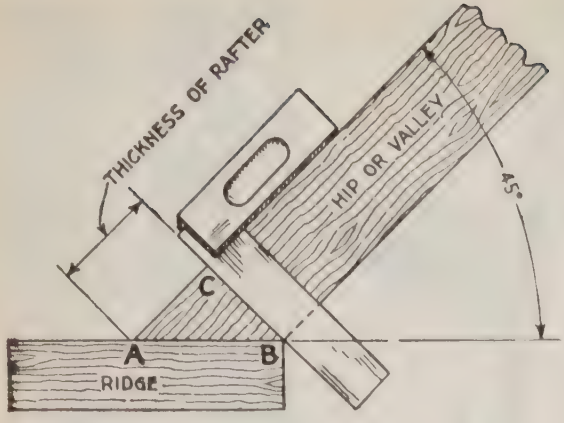


FIGS. 1,963 and 1,964.—Full tail hip and valley rafters showing all cuts. The mitre cuts are plainly seen.

After the plumb cut is made the end must be mitred *outward* for a hip as in fig. 1,963 and *inward* for a valley as in fig. 1,962 to receive the *fascia*.* The mitre cuts are shown more plainly in figs. 1963 and 1,964 which illustrate hip and valley rafters in place on plate.

Side Cuts of Hip and Valley Rafters.—These rafters have at the ridge end a *side* or *cheek* cut. In the absence of a framing square a simple method of laying out the side

*NOTE.—A fascia is a flat member of a cornice or other finish generally under the upper member of the cornice.



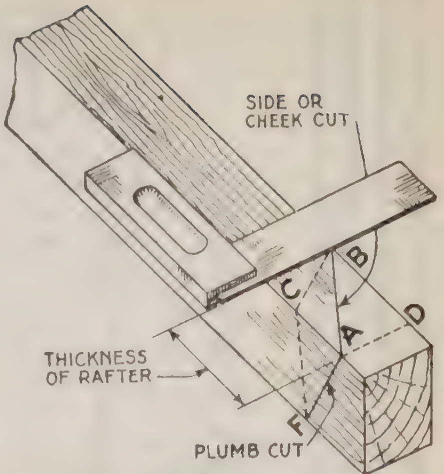
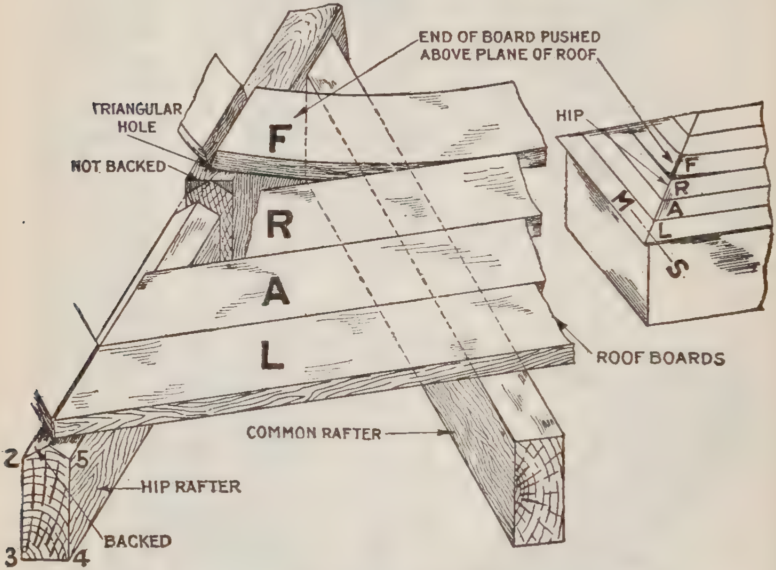


FIG. 1,965.—Method of obtaining side cut of 45° hip or valley rafter without aid of framing table. *Measure back on edge of rafter from point* **A**, *of top cut, a distance* **AC**, *equal to thickness of rafter. Square across from* **C**, *to* **B**, *on opposite edge and scribe line* **AB**, *which gives the side cut. Why?* The carpenter's knowledge of elementary geometry should be sufficient to explain why **AB**, obtained as above is the proper bevel for side cut.

FIG. 1,966—Lay out of top and side cut of hip or valley rafter. **FA**, top cut; **AB**, side cut. Here **A**, the point from which half thickness of rafter is measured, is seen at top end of top cut.

cut for a 45° hip or valley rafter * is as follows: *Having scribed the plumb cut, measure back along top edge a distance equal to the thickness of the rafter and from that point square across to opposite edge. Join the point thus found with the point from which the measurement was taken as in fig.* 1,965. This rule does not hold for any other angle other than 45°.

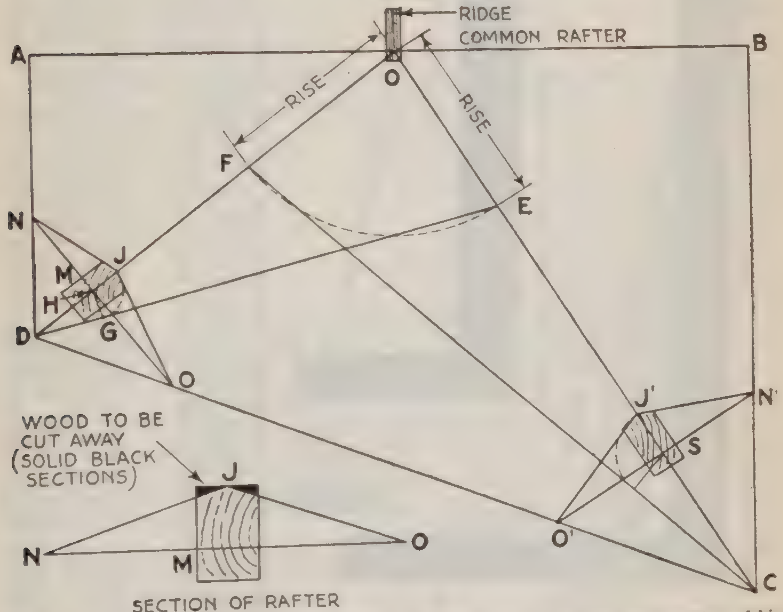
Backing of Hip Rafters.—By definition the term *backing* is the bevel upon the top side of a hip rafter which allows the roofing boards to fit the top of the rafter without leaving a triangular hole between it and the back of the roof covering.



FIGS. 1,967 and 1,968.—Backing of hip rafter showing lifting of roof boards without backing. Fig. 1,967, sectional view of the hip roof of building shown in fig. 1,968, LARF in fig. 1,968 corresponding to LARF in fig. 1,967. Since the hip rafter is measured along a line in the center of the top side, the corners of the upper edges of the hip will projecta bove the plane of the common rafters. Thus, in fig. 1,967, the hip is shown backed for the three boards LAR, hence they lie in the same plane as over the common rafter, but board F, is shown with its end against an unbacked portion of the hip. It is accordingly raised up out of the plane of the boards LAR, board F, and the opposite one, leaving the triangular hole, as shown.

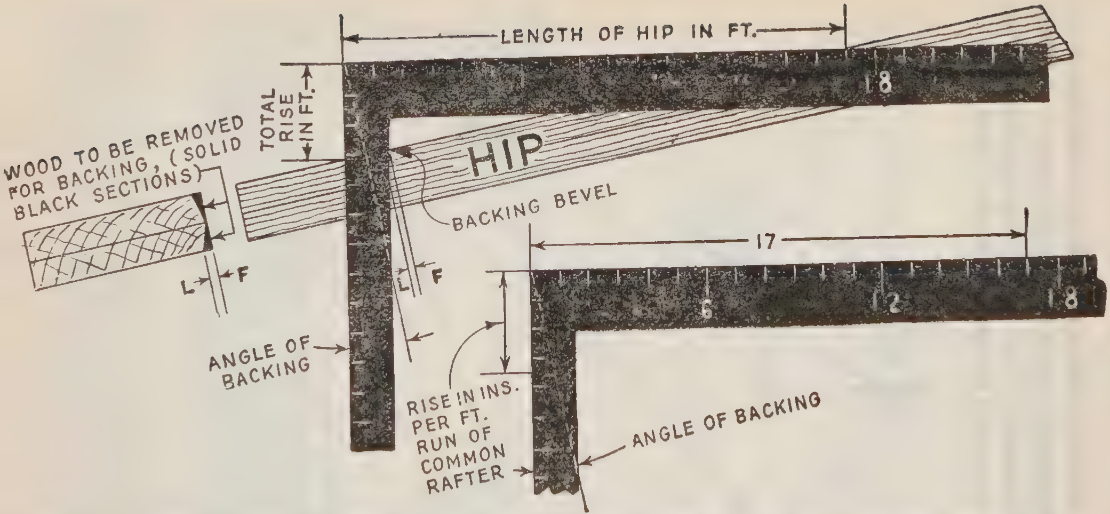
*NOTE.—The author prefers the term "45°" hip or valley for a rafter whose line of run makes 45° with the ridge, rather than the ridiculous expression "square cornered building," which means nothing. A building may be square cornered (walls meeting at 90°) and not even have any hip or valley rafters; again, it may be square cornered with the hip or valley rafters at any angle other than 45°. The top cut consisting of the plumb and side cuts should be made in one sawing rather than two; that is, the cut should be made by sawing along the lines FA, and AB, rather than FA, and AD (fig. 1,966), thus avoiding extra and unnecessary labor.

The triangular hole is of no importance, but it is the fact that unless the top side be beveled, or the plumb height reduced proportionally the roof boards will be pushed up too high by the edges of the hip rafter as shown in figs. 1,967 and 1,968.



FIGS. 1,969 and 1,970.—Graphical method of finding lengths of rafters and backing of hip rafters. Let AB, be span of building OD, and OC, plan of two unequal hips. Lay off the given rise as shown then DE, and CF, are lengths of the two unequal hips. Take any point as G, on DE, and erect the perpendicular cutting DF, at H. Revolve GH, to J, that is, make HJ = GH, and through H, draw NO, perpendicular to OD. Join J, to N, and O, giving bevel angle NJO, which is the backing for rafter DE. Similarly bevel angle N J O, is found for backing of rafter CF. Fig. 1,970 is section of M, showing in solid block the two triangular sections to be cut away.

The graphical method of finding the backing of hip rafters is shown in fig. 1,969, and 1,970, and the square method in figs. 1,971 and 1,972.



FIGS. 1,971 to 1,973.—Method of finding backing bevel for hip rafter with the square. Set square on rafter with total rise ((in ft. on tongue and length of rafter in ft. on body as shown, tongue gives bevel. In fig. 1,971, the projected distance LF, to center line is transferred to the end of the rafter as in fig. 1,972, and bevel laid as shown. Instead of taking total rise and total length in ft., as in fig. 1,972, the same result is obtained thus: take the rise in ins. per ft. run of common rafter on the tongue and the length in ins. of hip per ft. run of common rafter on the blade and scribe along the tongue to get the angle of backing, as in fig. 1,973.

Hip rafters are rarely backed upon common work, as there is not enough gained to make it advisable. In place of backing the plumb height of the rafter at the plate may be shortened a distance equal to the height of the backing. Although this method leaves a triangular hole between the roofboards and the hip, it is satisfactory as the nails are driven into the corners of the hip which are flush with the common rafters. Figs. 1,974 and 1,975 show method of reducing plumb height as a substitute for backing.

The Jacks.—As outlined in the classification there are several kinds of jack rafters as distinguished by their relation with other rafters of the roof. These various jack rafters are known as:

1. Hip jacks.
2. Valley jacks.
3. Cripple jacks.

The distinction between these three kinds of jack rafters as shown in figs. 1,976 and 1,977, is as follows: *Jack rafters which*

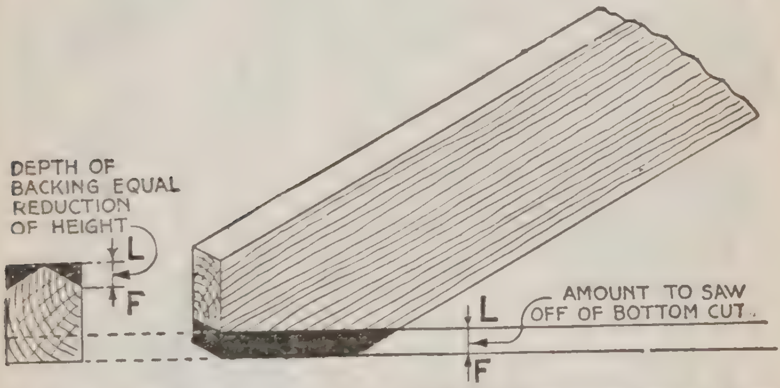
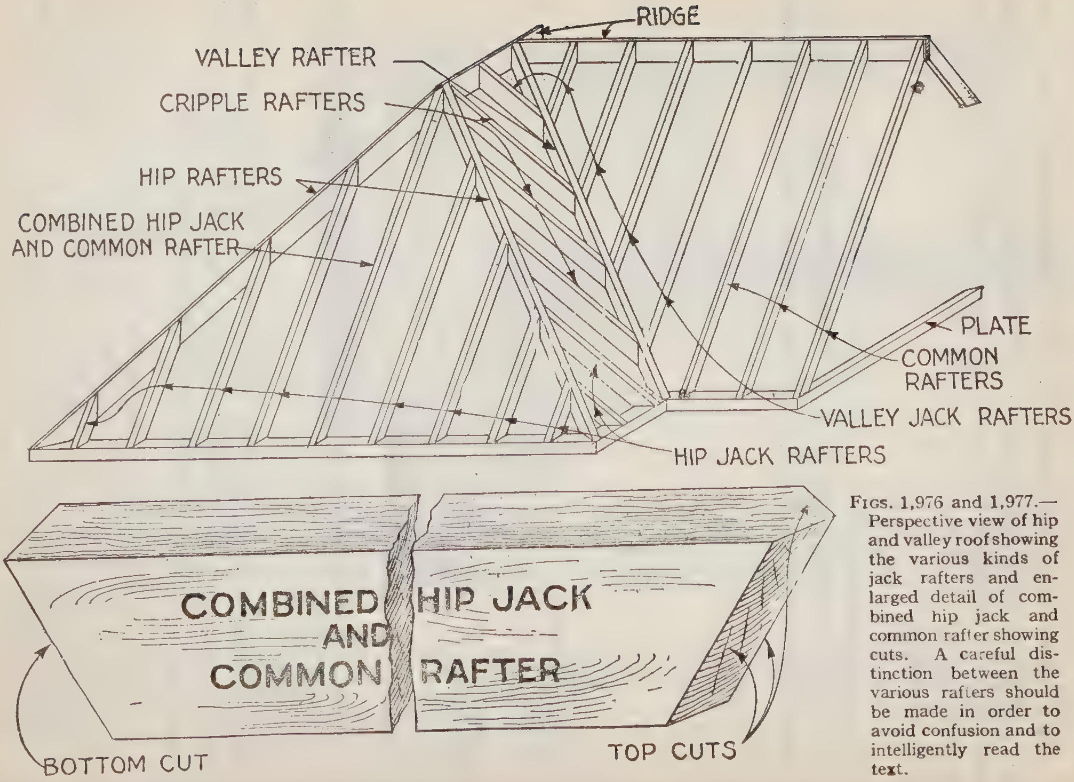


FIG. 1,974 and 1,975.—Method of reducing plumb height of hip rafter to avoid backing. It gives virtually the same result, that is, the roof boards are not pushed out of their plane, and it saves time and labor.

are framed between a hip rafter and the plate are ***hip jacks;*** *those frames between the ridge and a valley rafter are* ***valley jacks;*** *those framed between hip and valley rafters are* ***cripple jacks.***

The term cripple is applied because the ends or "feet" of the rafter are cut off, that is, the rafter does not extend full length from ridge to plate. From this point of view a valley jack is sometimes erroneously called cripple; it is virtually a semi-cripple rafter but the distinction is more sharply drawn and confusion avoided by confining the term cripple to rafters framed between hip and valley rafters as above defined.



Figs. 1,976 and 1,977.—Perspective view of hip and valley roof showing the various kinds of jack rafters and enlarged detail of combined hip jack and common rafter showing cuts. A careful distinction between the various rafters should be made in order to avoid confusion and to intelligently read the text.

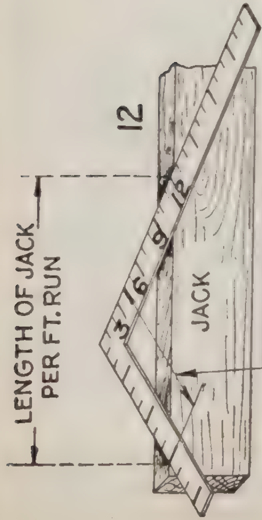


FIG. 1,978.—Application of the square using the number *12*, (as for common rafter) in finding length of jack per foot run.

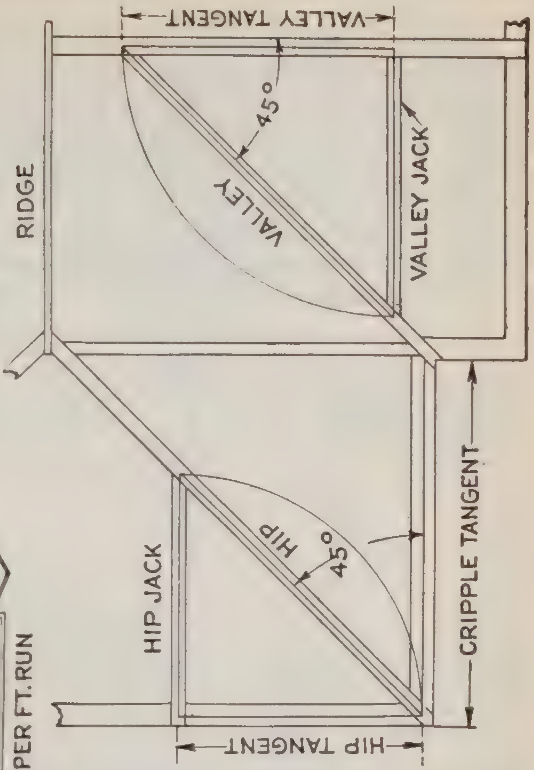
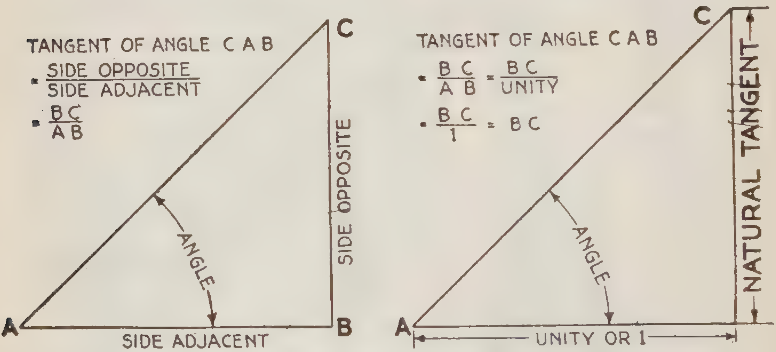


FIG. 1,979.—Plan of hip and valley roof showing tangents as referred to in finding lengths of jacks.

Length of Jack Rafters.—Since jack rafters are virtually "discontinued common rafters," that is, they are cut off by the intersection of a hip or valley or both before reaching the full length from plate to ridge, their lengths are found in the same way as for common rafters, that is the number **12** is used on one side of the square and rise in ins. per foot run on the other side. This gives length of jack rafter per foot run and is true for all jacks, hip-, valley-, and cripple-jacks.

1. The total length of a hip jack is equal to the hip tangent or



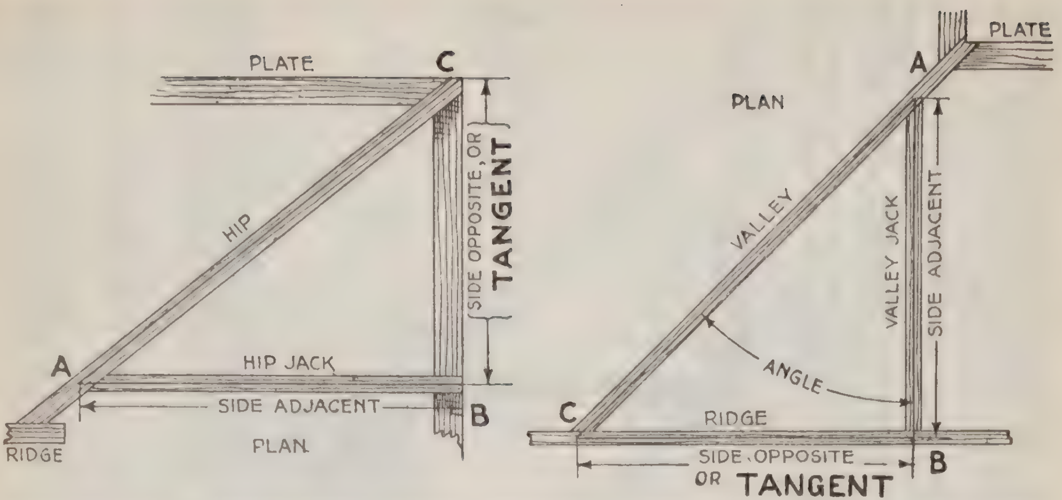
FIGS. 1,980 and 1,981.—Right angle triangles illustrating *tangent* and *natural* tangent.

distance intercepted on the plate between the foot of the jack and foot of the hip multiplied by length of hip jack per foot run.

Similarly:

2. The length of a valley jack is equal to the valley tangent of distance intercepted on the ridge between the upper ends of the valley rafter and valley jack rafter multiplied by length of valley jack per foot run.

3. The length of a cripple jack is equal to the cripple tangent or distance intercepted on the plate between the foot of the hip rafter and foot of the valley rafter multiplied by length of



FIGS. 1,982 and 1,983.—Hip, and valley roofs illustrating the tangent as used in finding the length of the hip-, or valley-jack rafter.

cripple per foot run. These rules for length of jacks hold when the hip and valley rafters are 45° rafters.

To understand these rules, a clear idea of the meaning of the word *tangent* is necessary.

By definition the tangent of a right angle triangle is equal to *the side opposite the angle divided by the adjacent side*, as shown in fig. 1,980.

Now if the side adjacent be taken as unity or one the denominator of the fraction disappears and the tangent in that case is equal to the side opposite as explained in fig. 1,981. This is the tangent as used in finding the length of jacks and is called the *natural* tangent.

The triangle in fig. 1,981 is shown in figs. 1,982 and 1,983 in its relation to hip and valley rafters illustrating that the run of a hip jack or valley jack is respectively equal to the hip tangent or valley tangent. In fig. 1,982 this is apparent from the arc described through A and C, with B, as a center.

The length of jacks as just obtained is taken along the top center lines and allowances must be made for the thickness of the hip, valley, or hip and

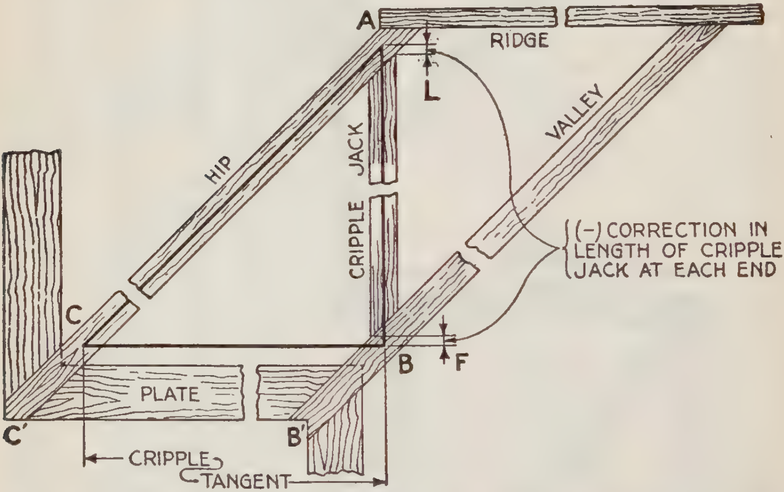
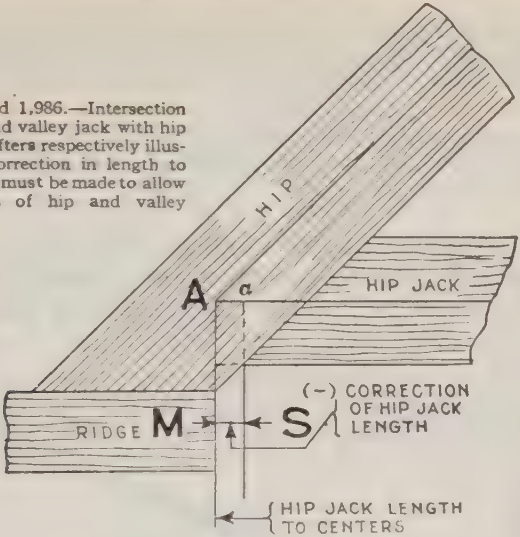
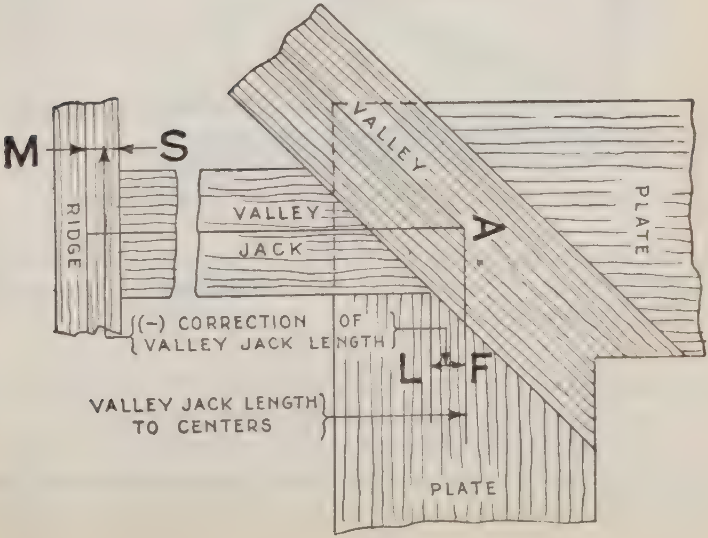


FIG. 1,984.—Hip and valley roof illustrating the tangent as used in finding length of cripple rafter and connection L and F, of length to allow for half thickness of hip and valley rafters. CB, is the cripple tangent and evidently since the hip and valley rafters are parallel CB, = C′B′, the intercept on the plate. Thus length of run of cripple rafter is equal to the *cripple tangent* or its *intercept* C B, on the plate.

valley respectively, for hip jacks, valley jacks or cripple jacks as the case may be.

Evidently in fig. 1,985 for hip jack the length must be reduced an amount A*a* or MS. (measured at right angles to the plumb cut) to allow for the half thickness of hip rafter S.





FIGS. 1,985 and 1,986.—Intersection of hip jack and valley jack with hip and valley rafters respectively illustrating the correction in length to centers which must be made to allow for thickness of hip and valley rafters.

Similarly in fig. 1,986 for a valley jack an amount **LF** (measured at right angles to plumb cut) must be removed at the lower end, and an amount MS, equal to half the thickness of the ridge (measured back from the top plumb cut).

In the case of a cripple jack a similar correction must be made at each end to allow for the half thickness of hip and valley rafter as L and F respectively in fig. 1,984.

In actual practice carpenters usually measure the length of hip or valley jack from the long point, along the arris, instead of along the center of the top, no reduction being made for ½

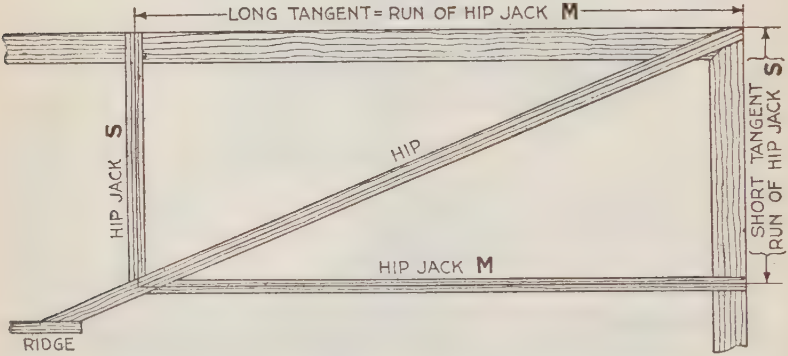
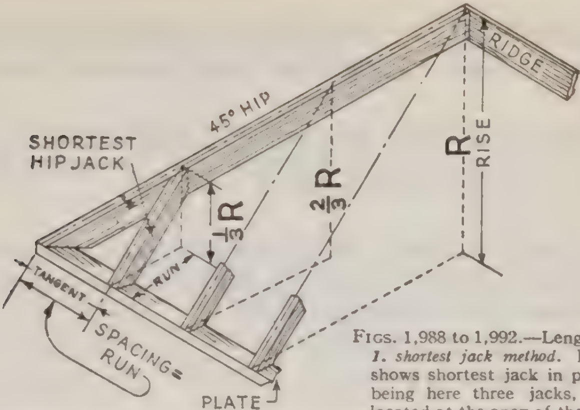


FIG. 1,987.—Hip roof end with unequal pitch illustrating long and short tangents.

diagonal thickness of hip or valley. Cripples are measured from long point to long point, no reduction being made for thickness of hip or valley.

Unequal Pitch; Long and Short Tangents.—In the preceding section *only* 45° *hip and valley rafters were considered.*

As often happens hip and valley rafters may be at some other angle giving rise to unequal pitch, that is, the jacks on one side of such hip or valley will be of one pitch and those on the other



FIGS. 1,988 to 1,992.—Length of jacks *1. shortest jack method*. Fig. 1,.988 shows shortest jack in place, there being here three jacks, the third located at the apex of the hip, being virtually a common rafter. Now with a 45° hip *the distance along the plate between centers of jacks is equal to the run as shown*, and the rise for the shortest jack is equal to 1/3 total rise. In

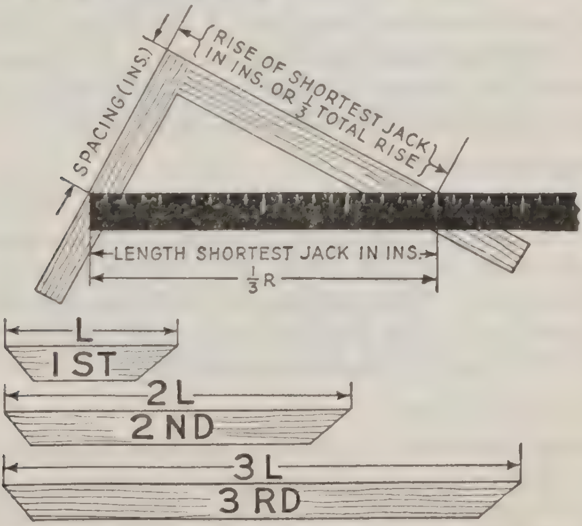


fig. 1,989, take on one side of square spacing in ins. and on the other side 1/3 total rise and the diagonal joining these points will be length of shortest jack in ins. This length will be the *common difference* in lengths, thus, second jack is twice length of shortest jack and third jack, three lines length of shortest jack, as indicated in figs. 1,990 to 1,992 (L, 2L, 2L).

side of another pitch. This gives rise to *long tangent* on one side and *short tangent* on the other side as clearly seen in fig. 1,987.

The illustration clearly shows that the *tangent* on the long side is the same length as the *run* on the short side. Also, the tangent on the short side equals the run on the long side.

Length of All Jacks.—As no two jacks are of the same length various methods of procedure are employed in framing, as:

1. Beginning with shortest jack.
2. Beginning with longest jack.
3. Using framing table.

Shortest jack method.

Begin by finding length of the shortest jack. Take its spacing from the corner measured on the plates which in the case of a 45° hip is equal to the jacks run. The length of this first jack will be the common difference which must be added to each jack to get the length of the next longer jack.

Longest jack method.

Where the longest jack is a full length rafter, that is a common rafter, first find the length of longest jack, then count the spaces between jacks and divide the length of longest jack by number of spaces. The quotient will be the *common difference.* Then frame the longest jack and make each jack shorter than the preceding jack by this common difference.

Framing table method.

On the various steel squares are tables giving the length of shortest jack rafters corresponding to the various spacings as 16, 20, and 24 ins. between centers for the different pitches. This length is also the *common difference* and thus serves for obtaining the length of all the jacks.

Example.—Find length of shortest jack or *common difference* in length of jack rafters where the rise of roof is 10 inches per foot and jack rafters are spaced 16 inches between centers; also, when spaced 20 inches between centers.

Fig. 1,993 shows reading of the jack table or the Eagle square, for 16

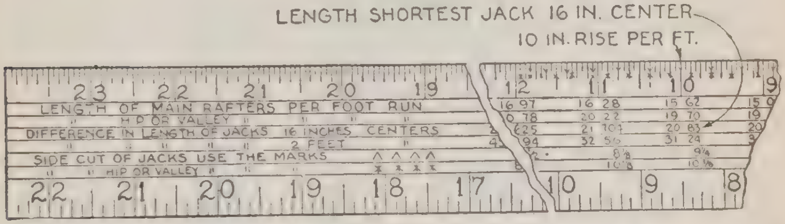


FIG. 1,993.—Framing tables of Eagle square showing reading for length of shortest jack or *common difference* for 16 in. spacing and 10 ins. rise per ft. run. ***Instructions:*** Under figure 10 which stands for rise per foot run, find in the third line of figures 20.83 which is length in ins. of shortest jack, 16 in. spacing.

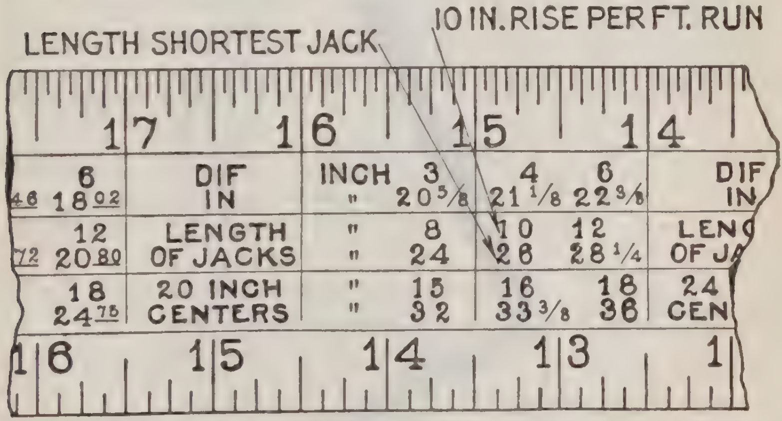
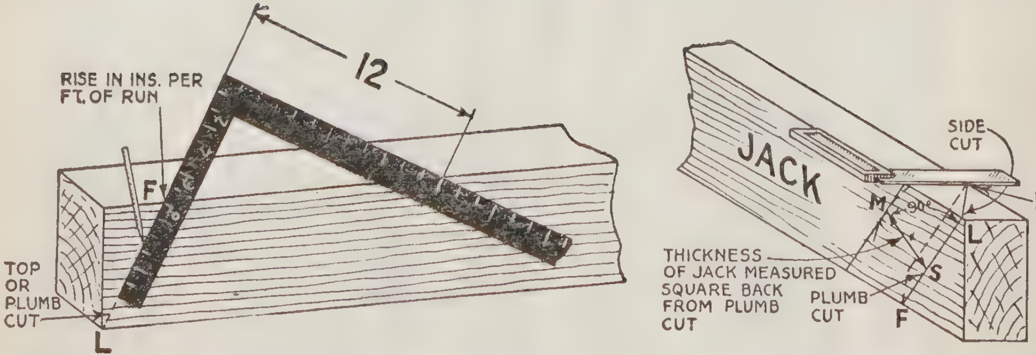


FIG. 1,994.—Jack table of Southington square for 20 in. spacing showing reading for length of shortest jack of *common difference* corresponding to 10 in. rise. ***Instructions:*** In the combination of figures shown the numbers 3, 4, 6, 8, 10, 12, 15, 16, 18 mean rise in ins. per foot run. The numbers under each of these figures give the length of shortest jack corresponding to the rise and for 20 ins. spacing. Hence, under rise 10 find 26, which is length in ins. for shortest jack, 20 ins. spacing.



FIGS. 1,995 and 1,996.—Method of finding plumb and side cuts of jack framed to 45° hip or valley. Apply square same as for common rafter, taking *12*, and rise in ins. per foot run (rise per ft. run = total rise common rafter ÷ ½ span) and mark plumb cut LF, as shown. ***To obtain side cut***, measure back at right angles the distance MS, (fig. 1,996) = thickness of jack carry up to top edge parallel to LF, and square across giving point R, and join L, and R, which gives the side cut, which is correct when jack is framed to a 45° hip or valley.

inch centers, and fig. 1,994, reading on the Southington square for 20 inch centers.

Jack Rafter Cuts.—Jack rafters have top and bottom cuts which are laid out the same as for common rafters, and also side cuts which are laid out the same as for a hip rafter. To lay off the top or plumb cut with square, take 12 on the tongue and rise in ins. (of common rafter) per ft. run on the blade and mark along the blade as in fig. 1,995. In the absence of a

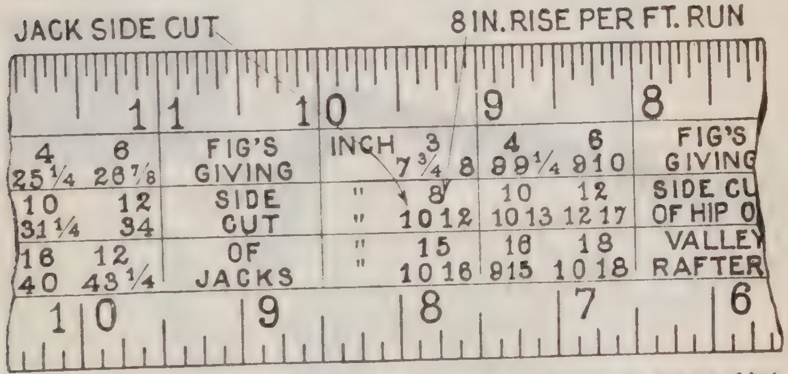


Fig. 1,997.—Jack side cut table of Southington square showing reading for side cut of jack corresponding to 8 ins. rise per ft. run.

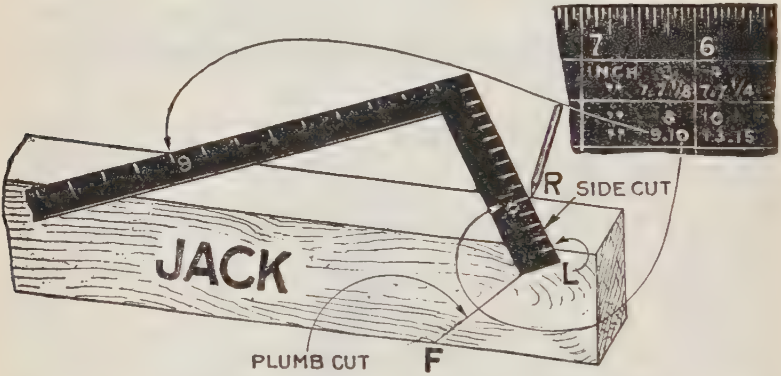
square with framing tables the side cut may be laid out as in fig. 1,996. The following example illustrates the use of the framing square in finding the side cut.

Example.—Find the side cut of a jack rafter framed to a 45° hip or valley for a rise of 8 inches per foot run.

Fig. 1,997 shows reading on jack side cut table of the Southington square and fig. 1,998 method of placing square on timber to obtain the side cut. It should be noted that different makers of squares use different setting numbers, but the ratios are always the same.

Side Cuts, Any Polygon; Method of Tangents.—The tangent value is made use of in determining the side cuts of jack, hip, or valley rafters. By taking a circle of radius 12 ins. the value of the tangent can be obtained *in terms of the constant of common rafter run.*

Considering rafters with zero pitch evidently in fig. 2,002 if the common rafter be 12 ft. long, the tangent MS, of a 45° hip is the same length. Hence, placing the square on the hip

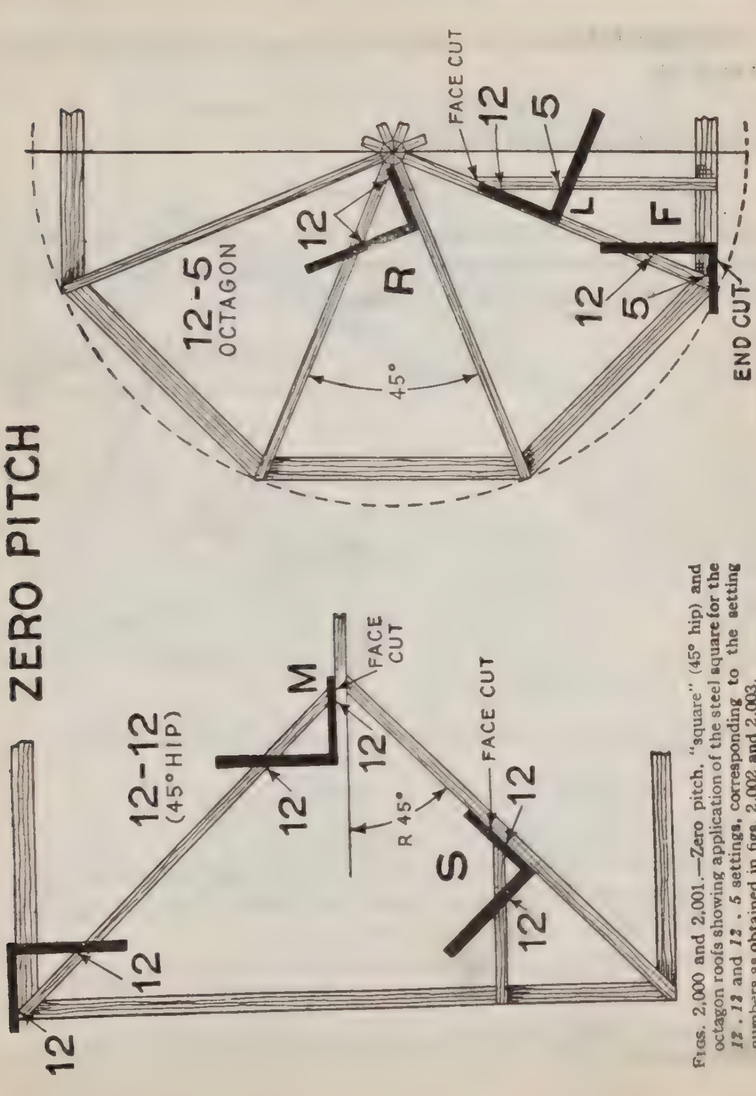


FIGS. 1,998 and 1,999.—Method of placing Southington square on jack to lay off side cut for 8 in. rise. Setting numbers 9 and 10 as shown in the portion of the table seen at the right.

set to 12 on tongue and 12 on body will give the side cut at ridge *when there is no pitch* as at M, fig. 2,000.

Placing square on jack with same setting numbers (12, 12) as at S (fig. 2,000) will give face cut for jack when framed to 45° hip with zero pitch, that is when all the timbers lie in the same plane.

For an octagon roof to find the tangent of octagon rafter requires some calculation, thus:



FIGS. 2,000 and 2,001.—Zero pitch, "square" (45° hip) and octagon roofs showing application of the steel square for the *12 . 12* and *12 . 5* settings, corresponding to the setting numbers as obtained in figs. 2,002 and 2,003.

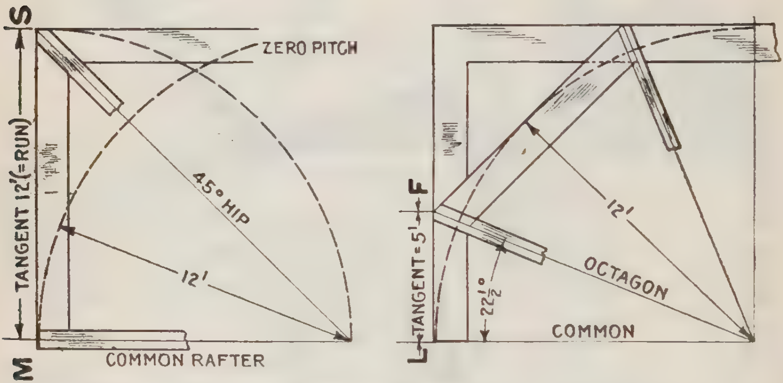
The angle between common and octagon rafters (zero pitch) is equal to

$$\tfrac{1}{2} \text{ of } 360° \div 8 = 22\tfrac{1}{2} \text{ degrees}$$

From table of natural tangents,

$$\text{tangent } 22\tfrac{1}{2}° = .41421$$

which is the length the tangent LF (fig. 2,003) would be if the length of common rafter were unity or 1 instead of 12. Hence since common rafter length is taken as 12, then



Figs. 2,002 and 2,003.—Zero pitch diagrams showing common, 45° hip, and octagon rafters with tangents.

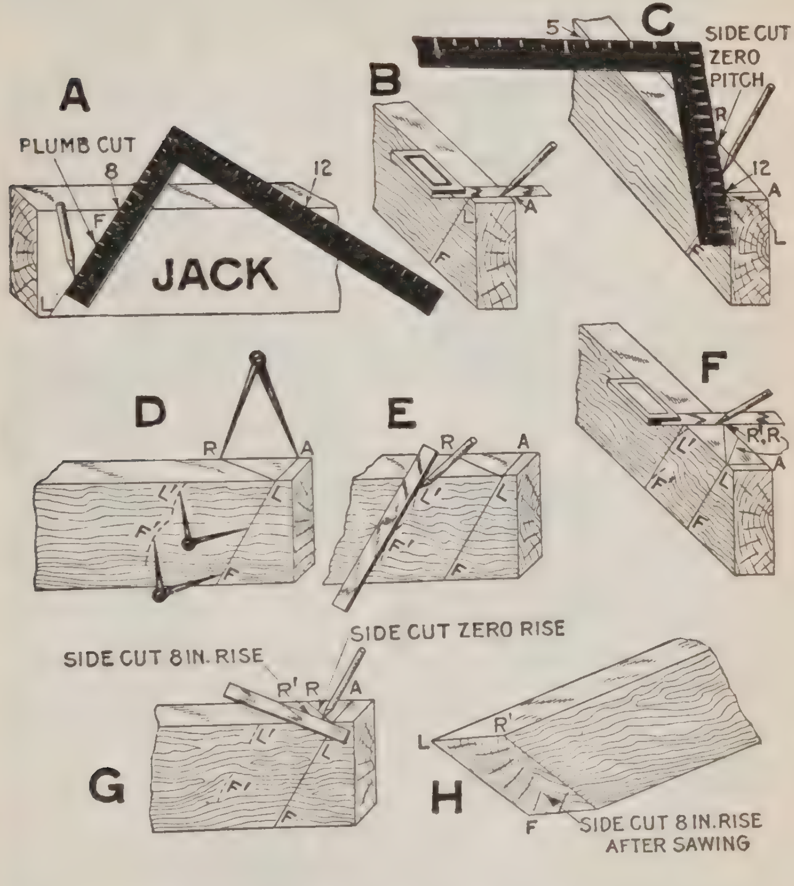
$$\text{length tangent LF,} = .41421 \times 12 = 4.97$$

which for ordinary purposes is taken as 5.

Accordingly, when there is no pitch, placing square on jack set to 12 on tongue and 5 on body gives face cut of jack framed to octagon rafter as at L (fig. 2,001).

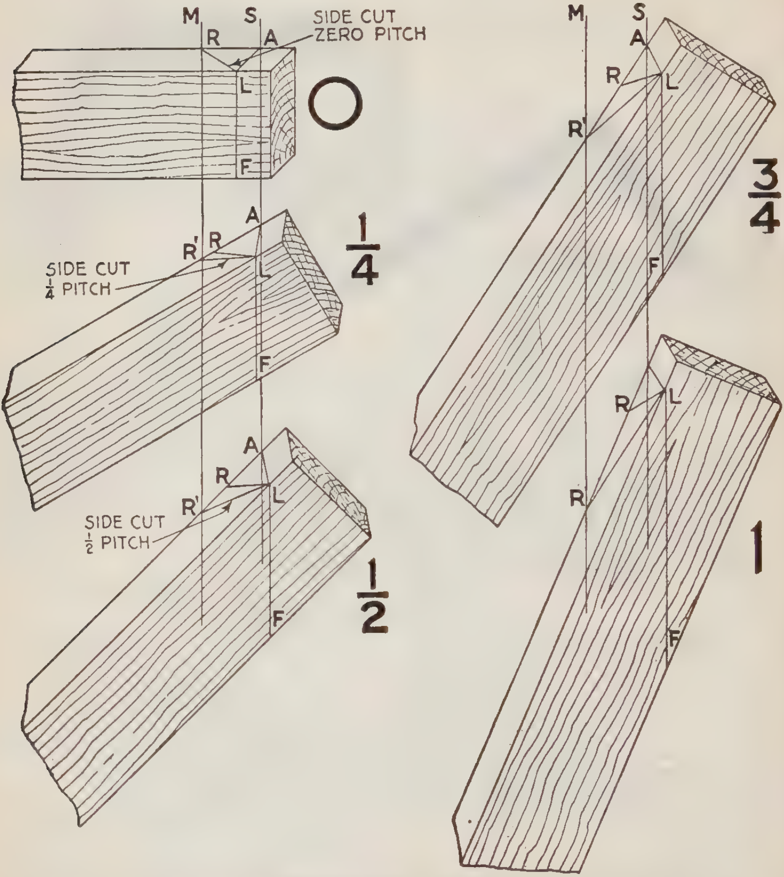
Similarly placing square at end of jack with same setting as at F, gives the end cut of jack.

Since in an octagon roof the octagon rafters are at 360 ÷ 8 = 45° apart same angle as between common or jack and 45° hip (fig. 2,000) the setting



FIGS. 2,004 to 2,011.—Method of obtaining side cut for jack rafter framed to octagon; pitch 8 in. per foot. **A**, plumb cut; **B**, plumb cut squared across top side of jack; **C**, side cut zero rise; **D** to **E**, side cut corrected for rise of 8 ins. per ft. run; **H**, appearance of jack after sawing.

numbers are 12.12. Hence placing square on octagon rafter set to 12 on tongue and 12 on body as at R, fig. 2,001 gives side cut. It will be noted



FIGS. 2,012 to 2,016.—Moving picture of side cut of jack of octagon frame for various pitches from zero to 1, showing angle of side cut becoming more acute as the pitch is increased. In the figures LR, is side cut for zero pitch, LR′ side cut for various pitches as indicated LF, plumb cut. The two vertical lines, M and S, indicate distance measured back of plumb cut at right angles to plumb cut. The lettering is the same as in figs. 2,004 to 2,011, with which they should be compared.

that the side cut extends only to center line of rafter there being a similar side cut on the other side, this being virtually a double side cut which is given to every other octagon rafter the alternates having only a plumb cut as shown.

The side cuts as obtained in figs. 2,000 and 2,001 are for timbers lying flat in one plane, that is, when the pitch is zero.

When rafters take on pitch or rise, the angles of the face cuts will change depending upon the pitch and the face cuts may be determined by the following method:

Example.—Determine the side cut of a jack rafter framed to an octagon rafter, the jack having a rise of 8 inches per foot run.

First mark off on side of timber the plumb cut using same method as for common rafter that is, placing square on timber set to ***12***, on body and 8 (rise) on tongue and scribing plumb cut LF, as in fig. ***A***.

On upper side of rafter square across the plumb cut with line LA, fig. ***B***.

Now, first assume no pitch and find side cut for no pitch by placing square across top side of rafter set to 12 and 5 and scribe line LR, side cut for zero pitch (fig. 2,001 shows at L, why this gives side cut).

Now since rafter has pitch a correction for cut LR, must be made, as follows:

With dividers pick off distance AR, and near ends of line LF, scribe arcs L′,F′, as in fig. ***D;*** scribe line L′F′ through these arcs as in fig. ***E;*** then will L′F′, be parallel to LF, and distance between these two lines equal to AR.

Square across top of rafter from point L′, scribing line L′R′ as in fig. ***F***.

Join R to L, then will R′L be side cut of jack framed to octagon rafter with rise of 8 inches per foot run of jack.

Fig. 2,011 shows appearance of jack after being sawed for side cut. The variation of the side cut for various pitches as compared with the side cut for zero pitches is clearly seen in the moving picture exposition, figs. 2,012 to 2,016.

13

Octagon Rafters.—On an octagon or eight-sided roof, the rafters joining the corners or octagon rafters as they are called

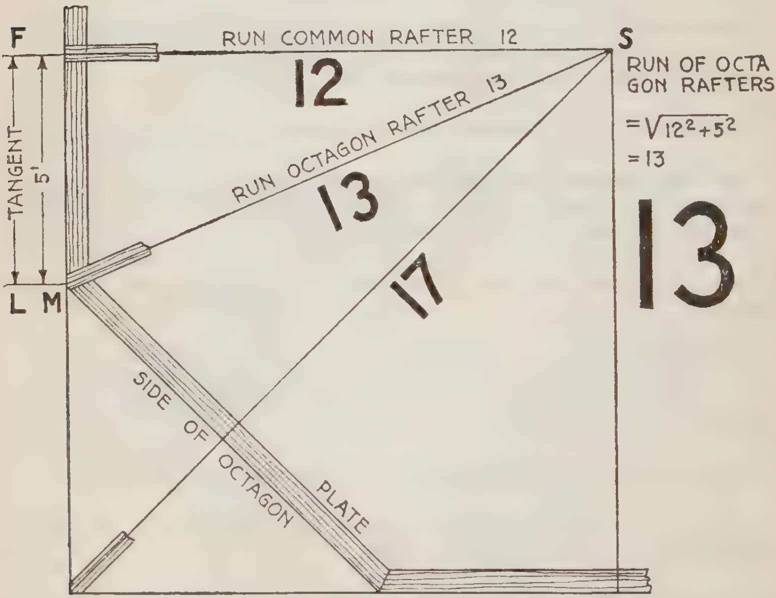
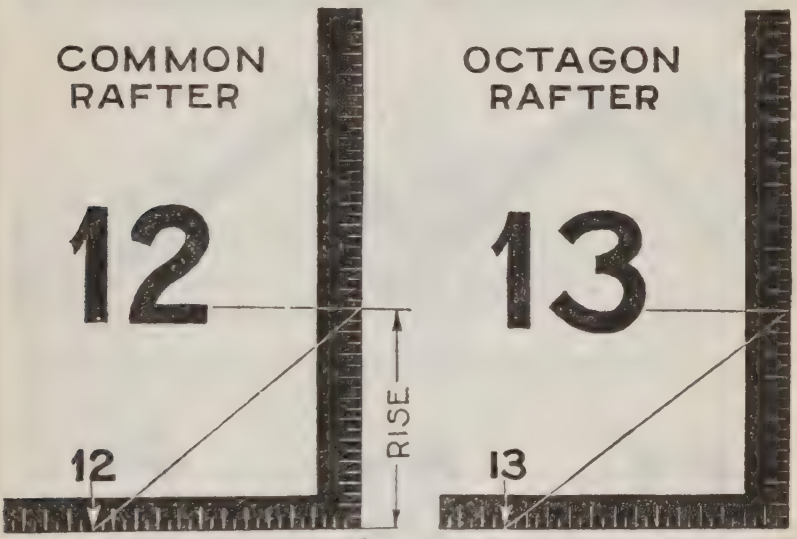


FIG. 2,017.—Detail of octagon roof showing relation in length between common and octagon rafters. Taking the common rafter run as *12*, then the tangent LF, as explained in the text is 5. Evidently then the run of octagon rafter MS, $= \sqrt{12^2 + 5^2} = $ ***13***, that is run of common rafter is to run of octagon rafter as 12 is to 13. Hence top and bottom cuts of octagon rafter can be laid off by taking *13* on tongue and rise per ft. run on body as in fig. 2,026.

are a little longer than the common rafter and shorter than the hip or valley of a square building of the same span.

The relation between the run of an octagon and a common rafter is shown in fig. 2,017, being as 13 is to 12. That is for



FIGS. 2,018 and 2,019.—Diagrams showing that for equal rise, the run of octagon rafter is 13 ins. to each 12 ins. of the common rafter.

each foot run of a common rafter, an octagon rafter would have a run of 13 ins. to rise to the same height. Hence to lay off the top or bottom cut of an octagon rafter, *place square on timber with **13** tongue and the **rise** of the common rafter per foot run on the blade* as shown graphically in figs. 2,018 and 2,019 and method of laying out top and bottom cut with the 13-rise setting as in fig. 2,020.

The length of an octagon rafter may be obtained by scaling the diagonal on the square for 13 on tongue and rise in ins. per

foot run of common rafter and multiplying by the number of feet run of common rafter.

The principle involved in determining the amount of backing of octagon, or rafters of any other polygon, is the same as for hip rafters, the backing being determined by *the tangent of the*

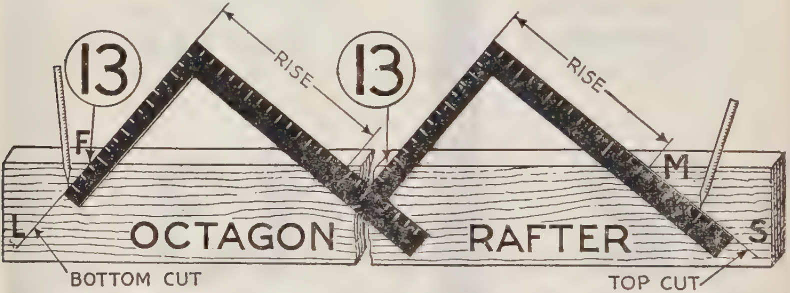
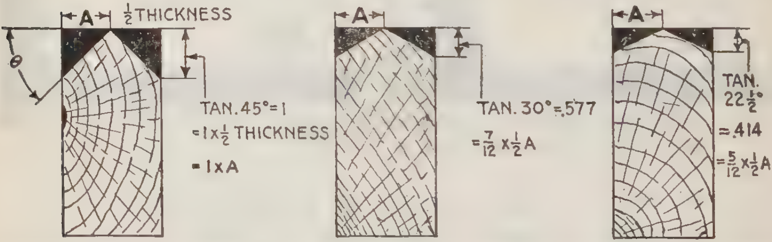


FIG. 2,020.—Method of laying off bottom and top cuts of octagon rafter with the square using the 13—rise setting. LF, bottom cut; MS, top cut.



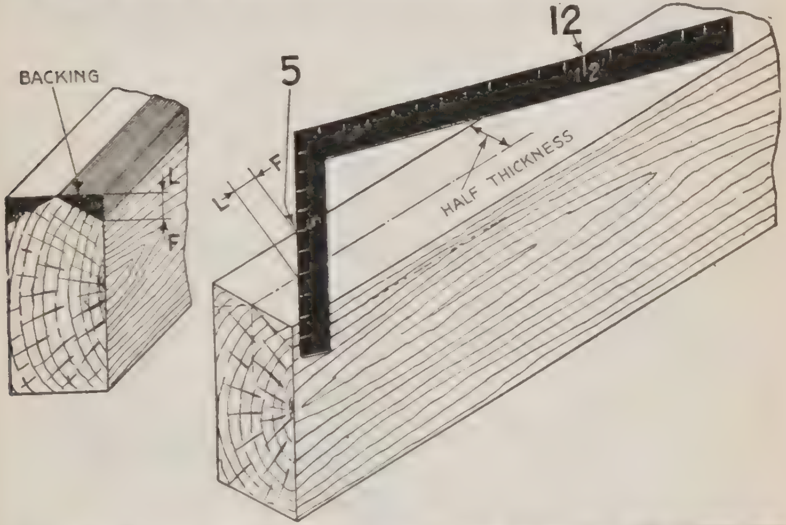
FIGS. 2,021 to 2,023.—Backing of hip of any polygon. Depth of cut on side of rafter is equal to tan θ × ½ thickness of top of rafter.

angle whose adjacent side is ½ the rafter thickness and whose angle is equivalent to one-half the central angle, as shown in figs. 2,021 to 2,023.

Graphic Method of Laying Out Roof Cuts.—This method of

laying out rafters is sometimes used on complicated roofs to check up the angles found by the steel square but its principal use is in solving problems in roof construction which are published in the periodicals that circulate among carpenters.

As an example, assume ABCD, fig. 2,026 to be plan of an irregular roof or one in which the side walls are not parallel to each other, but spread or



FIGS. 2,024 and 2,025.—Method of laying out backing on octagon rafter. Place square upon rafter as in fig. 2,025 with *5, 12*, setting, the 5 being the octagon tangent for run of *12* of common rafter. Measure back intercept of tangent to center line or distance LF and transfer it to side of rafter as in fig. 2,024, giving backing as shown by the two little solid black triangular areas representing section of word to be removed. LF, measured on plumb line, also represents amount of drop in case of no backing.

widen out from A, to B, and from C, to D, or BD, is longer than AC, and AB, is longer than CD; for this reason there will be two ridges, one parallel or equi-distant from each wall plate as EF, and EG, and what is called a "deck" will be formed on the top. Were this not done, all the common rafters would be of different lengths or the ridge, if they were supposedly sawn the same length would be out of level or slope downward from F, to E, so that in roofs of this kind it is always advisable and economical to employ two ridges because the deck will require only a slight pitch to drain off.

The seats of the needed hip rafters as AE, CE, BF, and DG, are found by bisecting each angle by the following method: In fig. 2,026, with the compasses or a rod, mark two points at the same distance from the apex of the angle A, and from these points sweep two arcs till they intersect or join at K. Join A, and E, by a line which will be the seat of the hip from A, to E, in fig. 2,027. A similar process if followed will give the lines for the seats of CE, DG, and BF.

Now to find the lengths and bevels of the common rafters proceed as follows: As in fig. 2,026, for those intended to be set up from UE, to VF, on

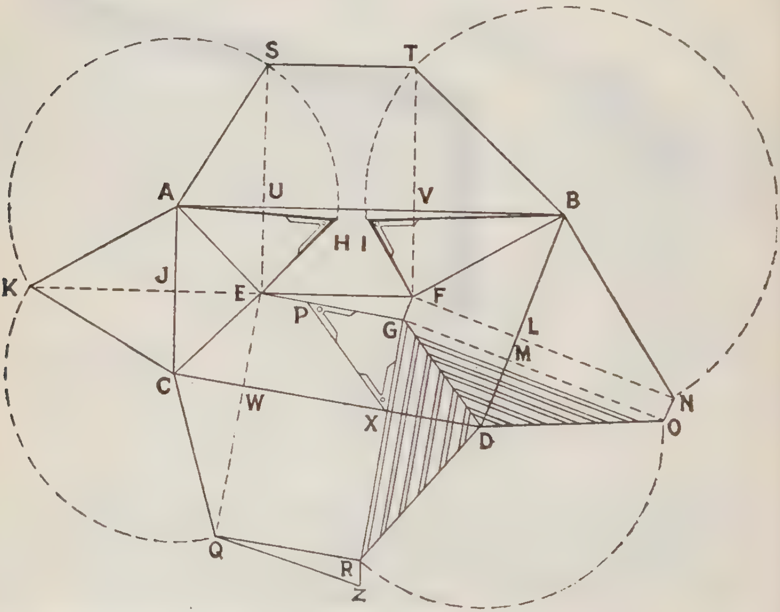


FIG. 2,026.—Graphical layout of irregular roof.

the far side, and from EW, to GX, on the near side, set up the pitch or height GP, square out from G, to X, and join PX, which line will be the neat length of the required pattern rafter, the top bevel or down cut being as at P, and the bottom or plate bevel as at X.

To obtain the length of hip rafters, square up from each point at the peaks as EH, and FI, on the further side, and make EH, and FI, each equal to

GP; AH, and BI, will be the lengths of the hip rafters which will rise over AE, and BF, and those which will be raised over the seats CE, and DG, are likewise formed by a similar method; also the bevels shaded in at the peaks and plates of each will be the top and bottom cuts of each.

It will be noted that no two of the bevels are alike so that each separate rafter must be laid out for its own particular corner as there are four hips of different lengths and different bevels so they must be carefully laid out and framed.

Regarding the jack rafters, these are shown on the right side, spaced out on the wall plate from X, to D, to fit against the hip GD, and their top and

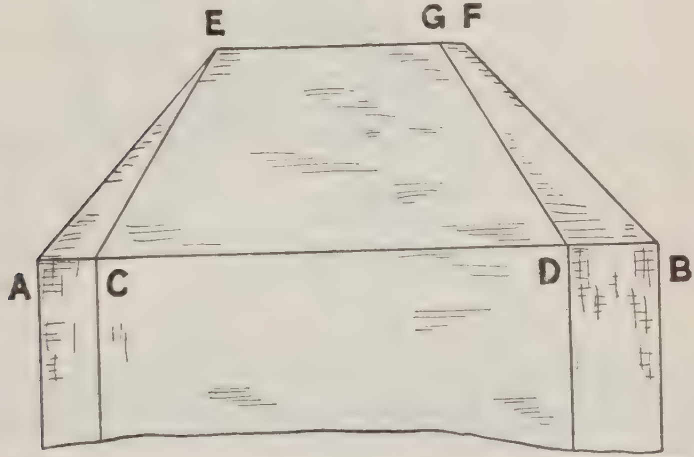


FIG. 2,027.—View of irregular roof shown in plan and laid out graphically in fig. 2,026.

bottom bevels or plumb and horizontal cuts will be the same as at P, and that at R, will be the side bevel. Similarly with those from D, to M, the plumb cut will be the same as P, and the bevel will be that at O.

In order to prove the layout of this roof, proceed to develop its planes or sloping sides by first drawing EUS, from E, at right angles to EF, or AB also draw FVT, parallel to EUS. Make AS, equal to AH, by taking A, as center with radius AH, and striking the arc HS, and through S, draw ST parallel to AB. If a center be taken at B, and an arc struck at ITN, it will be found that the arc will pass through T, or FV, produced at T. The surface ASTB, will cover the plan AEFB, on the pitch or roof slope EH.

Draw EJ, perpendicular to AC, and produce it to K. Describe curve HS, to K, and join AK, and KC. AKC will be the covering plane which will enclose AEC on the plan.

For the plane of CEGD, draw EW, perpendicular to EG, and produce it to Q. With C, as center and CK, as radius, strike the arc KQ, draw QR, parallel to CD, and join CQ, which will be the center line of the hip rafter on this side. Draw GX, perpendicular to CD, and produce to R; join RD; CQRD, will be the plane which will cover over CEGD, on the pitch GP.

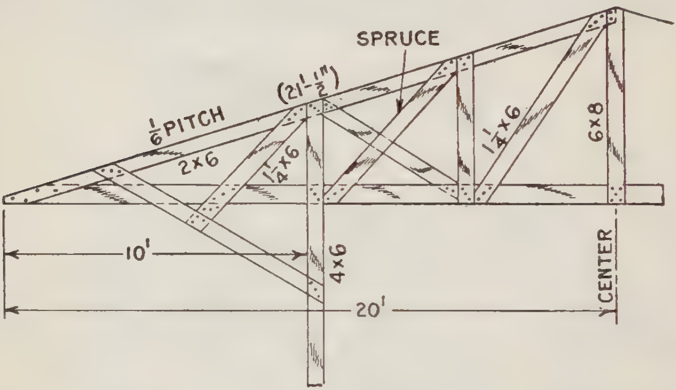


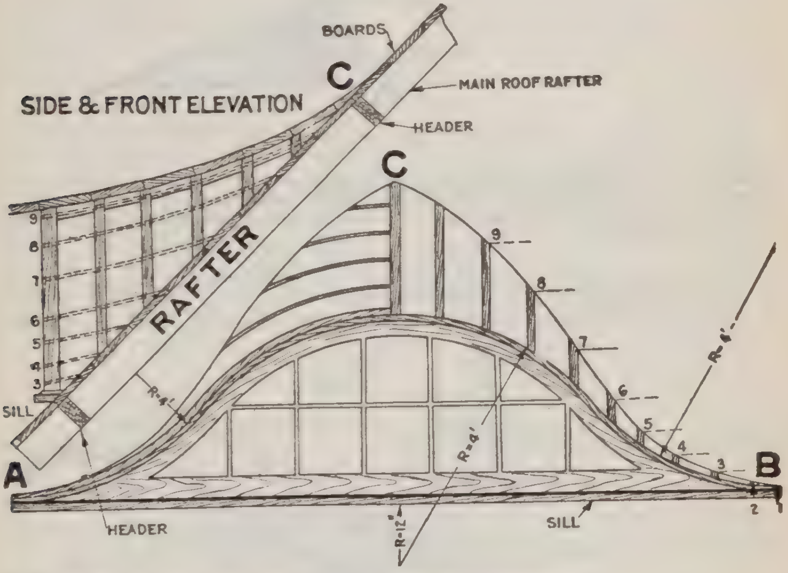
FIG. 2,028.—Inexpensive cantilever type single stringer external brace truss construction. The truss is entirely spiked together. The braces being nailed to the outside of the core or lower chord and main rafter, these can be of hemlock but preferably of spruce. The struts (braces) must be of spruce or a like tough wood. It is suited for a grand stand or shed overhanging a driveway. The size of purlins will be governed by the distance apart of the trusses and the weight of roof to be carried.

Now draw GM, and FL, perpendicular to BD, and produce them to N, and O. With D, as center and DR, as radius describe the arc RO. With radius BT, describe the arc TN, and join NO, and NB; BNOD, will cover the trapezoid plan BFGD, on the pitch GP. QRZ will be the covering of the deck being the same size or area as EFG.

In fig. 2,027, a side view or elevation of this roof will be seen as it will look when framed, raised and boarded over and to prove its correctness a model may be made by laying out all the lines on cardboard and making a knife slit from A, to B, from B, to D, from D, to C, from C, to A, also from Q, to R, which on being folded up together will give the completed roof with lines showing all the rafters, jacks, cuts and bevels in their proper positions.

Method of Framing "Eyebrow" Window in Roof.—This style of window has become popular for many of the Queen Anne and colonial bungalows and cottages, so some idea of its construction should be known to all carpenters.

In fig. 2,030, let AB, be length of window, say 6 feet long, draw the center plumb line DEC, and the two perpendicular end lines from A, and B, and



FIGS. 2,029 and 2,030.—Layout for eyebrow window framed in roof.

square to the level sill line AB. Next trace the curved eyebrow outline ACB, which must, of course, be copied from the architects design, also the parallel lines denoting the projections of the window frame casings sash as shown in fig. 2,030.

Next proceed to lay out the section by drawing the house rafter at its pitch as represented in fig. 2,029, and at the fixed distance up from the eaves or wall plate line draw in the 2 × 6 inch pitched window sill and measure up the height as indicated, namely 3 feet.

Assuming the short rafters of this window to be concave or of hollow curvature as seen, strike them out from one pattern at a radius of 8 feet and locate the intersection point C, in fig. 2,030, where the covering of the window roof meets that of the main house roof. Now divide the eyebrow curve into any

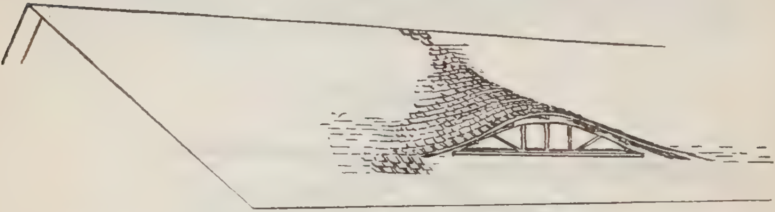


FIG. 2,031.—View showing appearance of eyebrow window. This type of window is only employed by the architect where it will be in good proportion to that part of the roof and at the same time will give sufficient light or ventilation, where another style would not harmonize with the design.

number of equal parts and transfer them over to fig. 2,029, and with the 4-foot center radius and patterns, draw the curves of all the rafters according

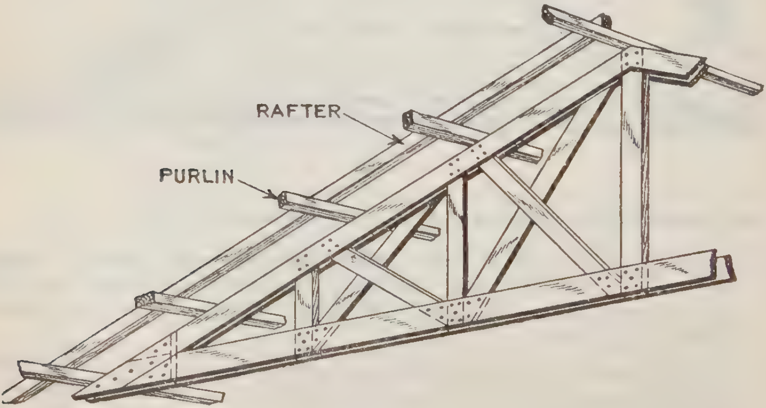
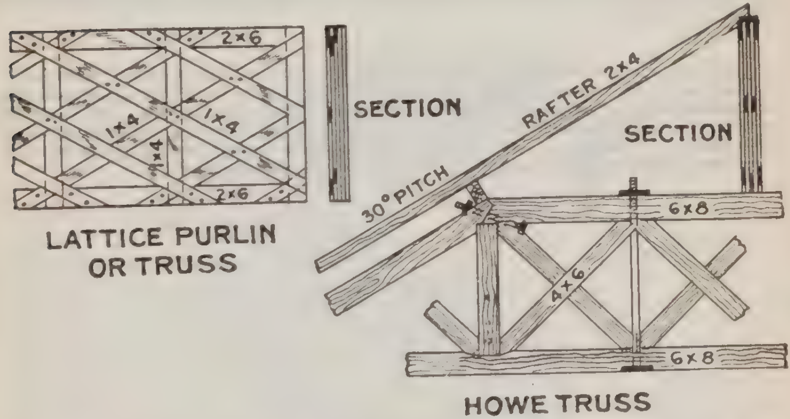


FIG. 2,032.—Double stringer internal brace truss construction.

to the number desired right and left, that is if the roof is to be boarded horizontally, as 1, 2, 3, 4, 5, 6, 7, 8, etc., which will be the curve and length of each and be set up in place as shown on the right side of fig. 2,030.

Now transfer from fig. 2,029 to fig. 2,030, section to elevation, the points where the curved eyebrow window rafters die into the main roof, and up square from division points on curve, the intersection of these lines will give the curve CB, which will be the shape of the valley at the main roof.

If desired the vertical curved rafters can be sheathed with one-half inch pine strips bent round in two thicknesses, well nailed to each rafter and breaking joint in each thickness.



FIGS. 2,033 and 2,034.—Trussed roof construction showing home truss and lattice truss purlin. On one side the lattice is spiked or nailed to the chords, first all the strips one way and then the others crossing on opposite angle. On the other side is nailed the vertical or upright pieces nailed at all crossings with right thickness.

Another way by which this attic roof may be framed would be to use horizontal instead of vertical curved rafters, each following the outline of the front elevation of the window and dying into the main roof as it curves upward.

Regarding slating or shingling these roofs, of course the first projecting course must follow the curvature of the eyebrow and diminish shingle by shingle to the point C, at the apex or top, this will take time, patience and skill.

The eyebrow type of window while pleasing architecturally, is relatively more expensive by reason of the curves necessary to intersecting shingles with other roof shingles and continuing them in regular courses over its roof.

To do this the depth of courses must be so uniformally graduated as to show the least possible variation, necessarially entailing more work selecting and shaping widths of shingles to suit the curves and prevent leaks. They are likewise more expensive to repair.

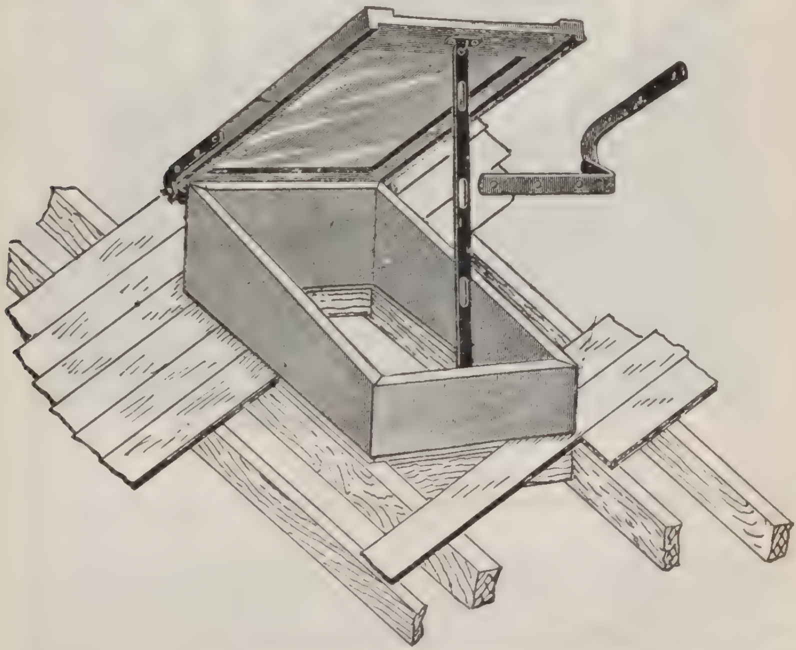
Their development and use is the result of efforts to secure more graceful and pleasing sky lines in roofs where either light or ventilation is needed, or both so placing them as to best conserve the architectural intent, their proportion conforming to roof dimensions or area in which they must be placed. When for light only, a much lower sash may be used permiting their nestling closer to roof.

NOTE.—All rafter lengths are measured down the middle of the top edges theoretically. On the square cornered roof, measurements of hip or valley rafters may be made from the long point without further reduction in length providing a 2″ thick ridge is used. Jacks need no further reduction in length on a square cornered building provided the hips or valleys are of the same thickness, as the jacks and the measurements are made from the long points of the jacks. Otherwise suitable reductions must be made for rafter and ridge thickness.

CHAPTER 43

Skylights

In carpentry, a skylight is any window placed in the roof of a building, or ceiling of a room for the admission of light and usually also for ventilation. Skylights are very essential to



FIGS. 2,035 and 2,036.—Hinged skylight framed into roof and detail of hinge. The box is of wood and may be made any size that will permit a person passing through it, even small enough to erect it without necessity of cutting out beams or rafters set on 16 in. centers.

lighting and ventilating top floors, under roofs that have little light, and in factories for both light and ventilation where the roofs are flat and where there is not much side light.

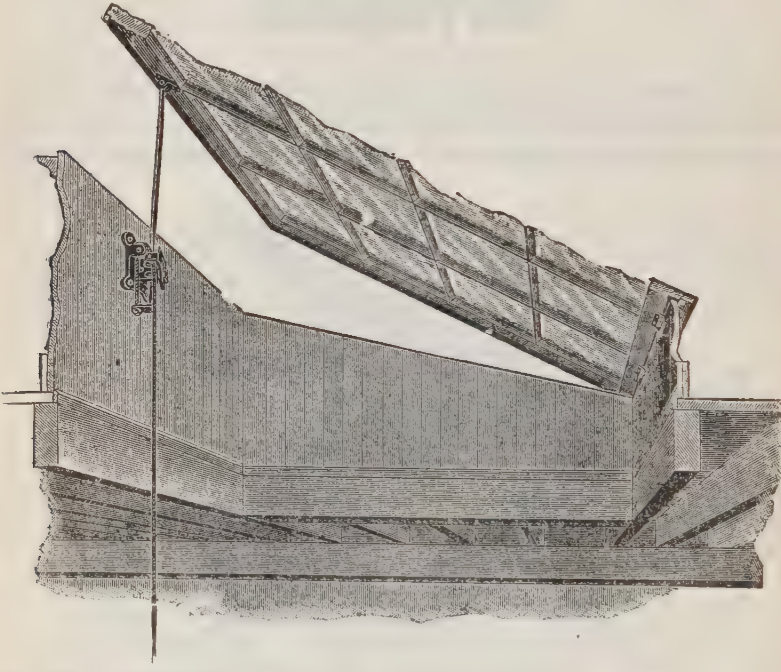


Fig. 2,037.—Sectional view of large hinge skylight and control.

Figs. 2,035 and 2,036 show a simple hinged skylight and detail of hinge. The skylight may be operated from below by the control device, there being adjustment eyes in the support ship as seen for securing the hinged sash at various degrees of opening.

Fig. 2,037 shows a larger hinged skylight, the section illustrating clearly the framing. Often a skylight is placed at the top of a flight of stairs leading to the roof, the projecting structure having framed in it the skylight and a doorway as in figs. 2,038 to 2,044.

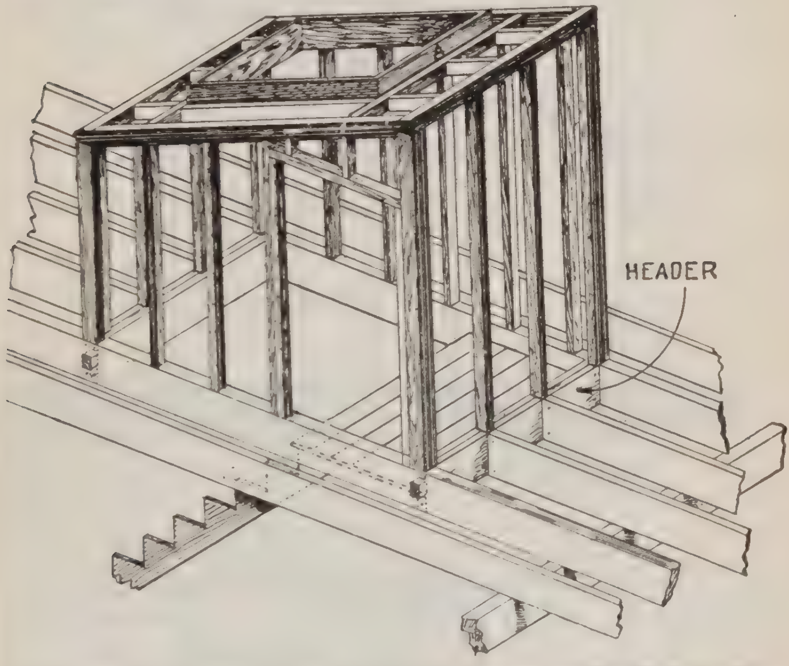
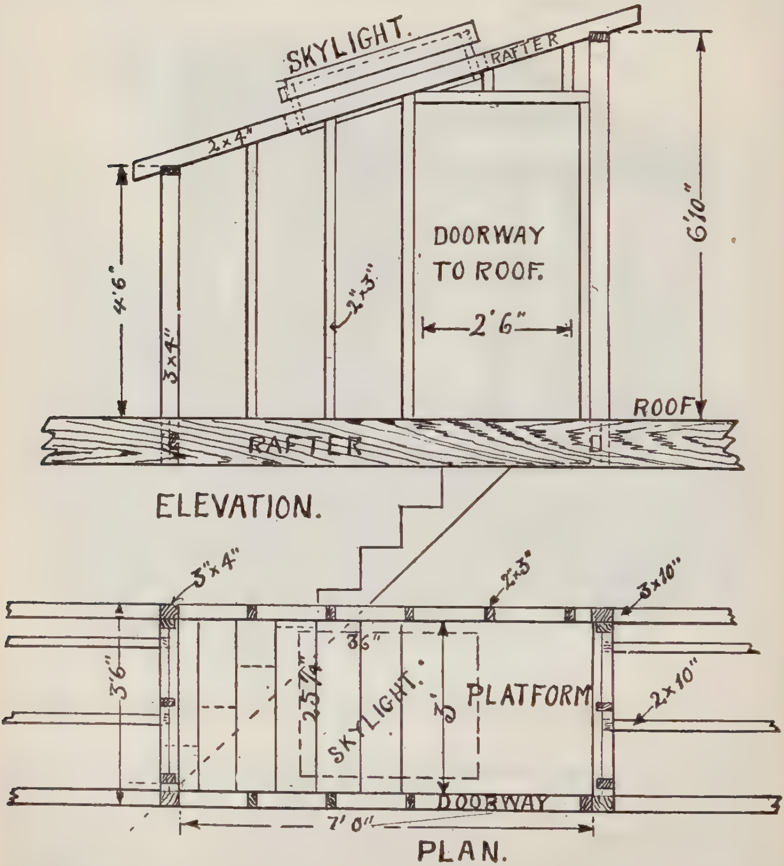


Fig. 2,038.—View of entrance to roof, or projecting framework containing framed openings for skylight and doorway.

Where fireproof construction is required, skylights are made of metal as shown in figs. 2,045 and 2,048. Side pivoted sash are shown in fig. 2,045, a type desirable for engine and boiler rooms where much steam is generated and much heat radiated and where some storm coming through them would do little

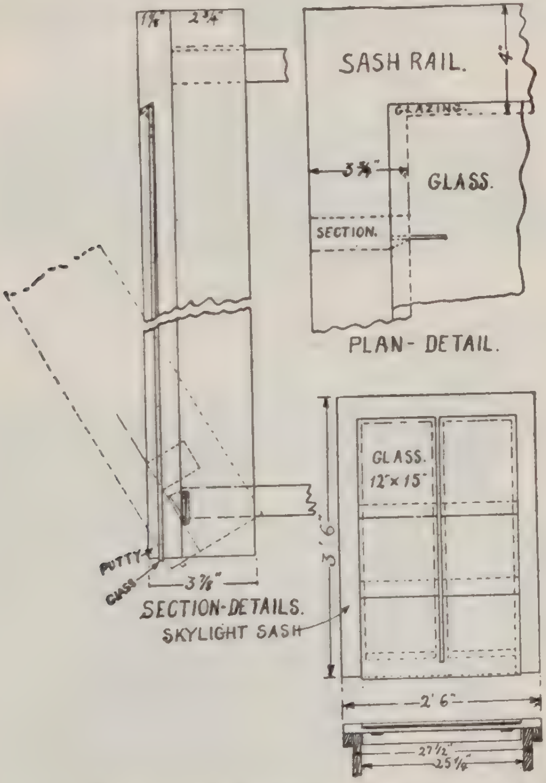
harm if thoughtlessly left open, and in any case where much heat, gases or vitiated air is to be taken out. The sash may be operated separately by pulleys, or all on one adjuster. The ends may be stationery.



FIGS. 2,039 and 2,040.—Elevation and plan of framework for roof entrance with skylight dimensions given.

The skylight shown in fig. 2,048 has ventilators built into the ridge.

These ventilators are water tight, and are always open unless a damper



FIGS. 2,041 to 2,044.—Skylight details for skylight of roof entrance shown in figs. 2,038 to 2,040 with dimensions.

be installed for reducing or stopping draught. They are made with and without damper. The all metal skylights are made to any size and shape required, but it is always best in roof designing to plan for standard sizes.

For skylights wire glass should be used so that if broken it will not fall and possibly injure someone below. Wire glass is cast with wire netting running through its center and is manufactured in many styles and sizes. Where light is to be furnished through doors the top half may be glazed and skylight omitted. Figs. 2,046 and 2,047 show two forms of wire glass. The approved method of fastening the glass is by retaining bars which are used instead of putty as in fig. 2,049.

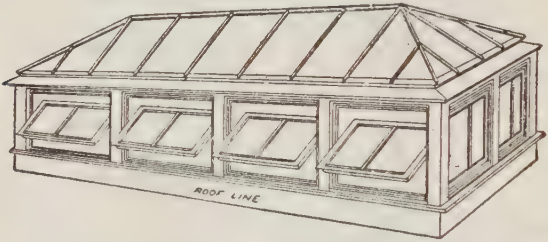
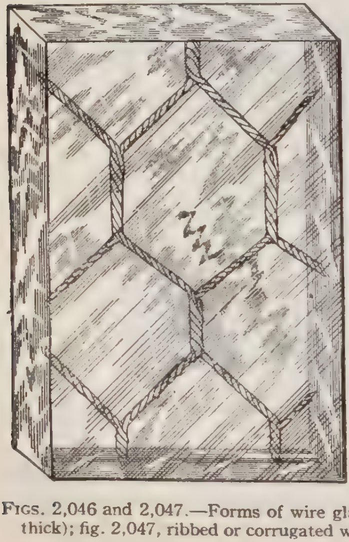
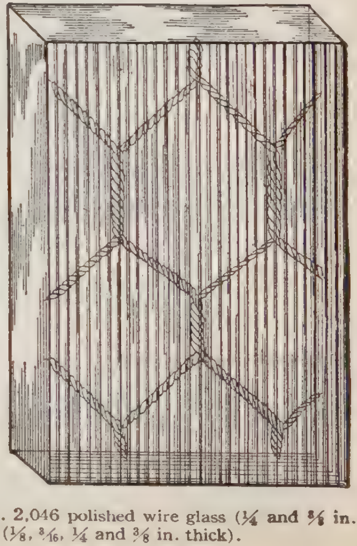


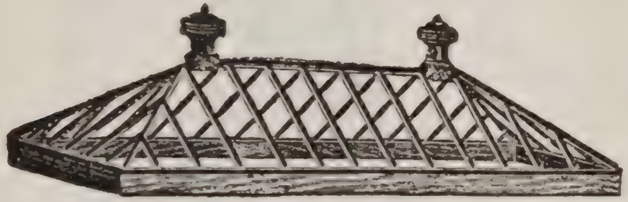
FIG. 2,045.—Metal fireproof ventilating skylight with pivoted sash. A type desirable where considerable lighting and ventilation are desirable.





FIGS. 2,046 and 2,047.—Forms of wire glass. Fig. 2,046 polished wire glass (¼ and ⅜ in. thick); fig. 2,047, ribbed or corrugated wire glass (⅛, $^3/_{16}$, ¼ and ⅜ in. thick).

For flat roofs a reinforced slab skylight is sometimes used as in fig. 2,056. The figure shows an iron web (grid of steel) or core placed in position, the glass prisms placed and finally the cementing done which is seen finished flush with the glass.



FIGS, 2,048—Galvanized iron skylight with acorn ventilators.

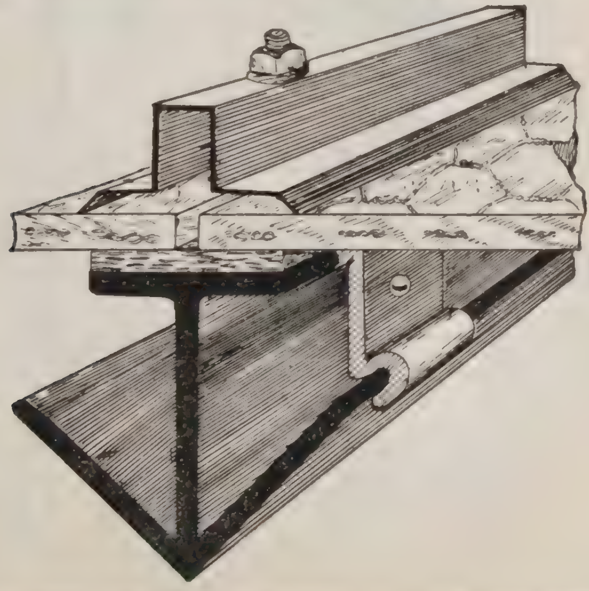


FIG. 2,049.—Sectional view of skylight glass retaining bar. A metai clamp securely attaches the bar to the I beam purlins.

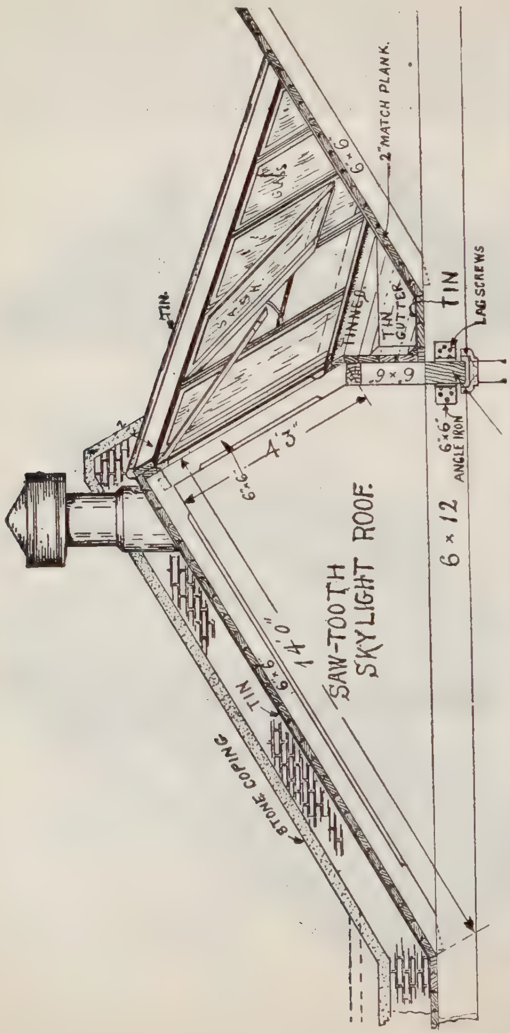
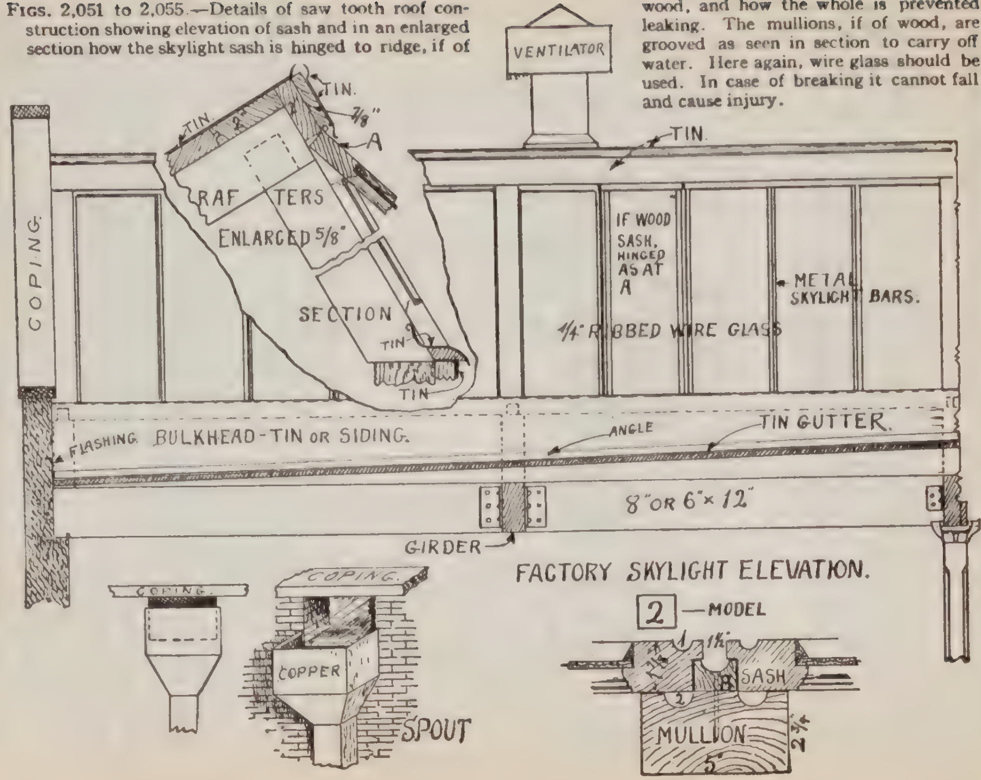


FIG. 2,050.—Saw tooth roof construction illustrating skylights. ***This type*** of roof is especially adapted to lighting one story factory building as can be readily seen by the amount of glass in each "tooth."



FIGS. 2,051 to 2,055.—Details of saw tooth roof construction showing elevation of sash and in an enlarged section how the skylight sash is hinged to ridge, if of wood, and how the whole is prevented leaking. The mullions, if of wood, are grooved as seen in section to carry off water. Here again, wire glass should be used. In case of breaking it cannot fall and cause injury.

These slabs are very strong, and when the spans do not exceed 12 feet, may be walked upon with safety. Sometimes an entire roof of factory is thus covered and lighted.

Figs. 2,051 to 2,055 show details of skylight construction in saw-tooth roof. Unless for some important reason, it is best to put the glass in stationary and ventilate with approved ventilators as indicated. If skylight sash be movable, it is important to have the ventilators for the purpose they serve in stormy weather when the sash cannot be opened. However a

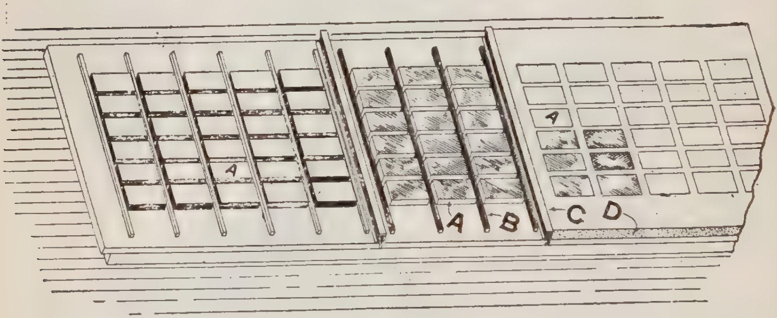


FIG. 2,056.—Reinforced slab skylight. The glass prisms are secured in the iron web by cement. A the glass, B reinforced iron or rod, C iron beam, D cement or concrete.

less number may suffice. The grooved center strip of mullion B, is securely nailed fast and painted. The sash are rabbeted so that any water, not carried off in groove 1, will accumulate in its groove, and any finding its way under sash will be carried off in groove 2.

When it is desired to carry off the water from the valleys on the outside of building a way is suggested by a copper hopper spout that receives the water through the breast work. With such a hopper there is no trouble by freezing. The roof covering is turned down outside of wall so as to fall over the inside edge of hopper. When not done this way the conductors (leaders) may be placed on the inside of building, thus saving the brasure or opening in cheek. This is a very practical way if there be heat enough inside to prevent spout freezing.

When the bulkhead—the space from the roof or top of girder to plate—is deep enough it should be so trussed as to greatly relieve the stress on the girder.

CHAPTER 44

Porches

The terms porch, piazza and veranda are usually applied

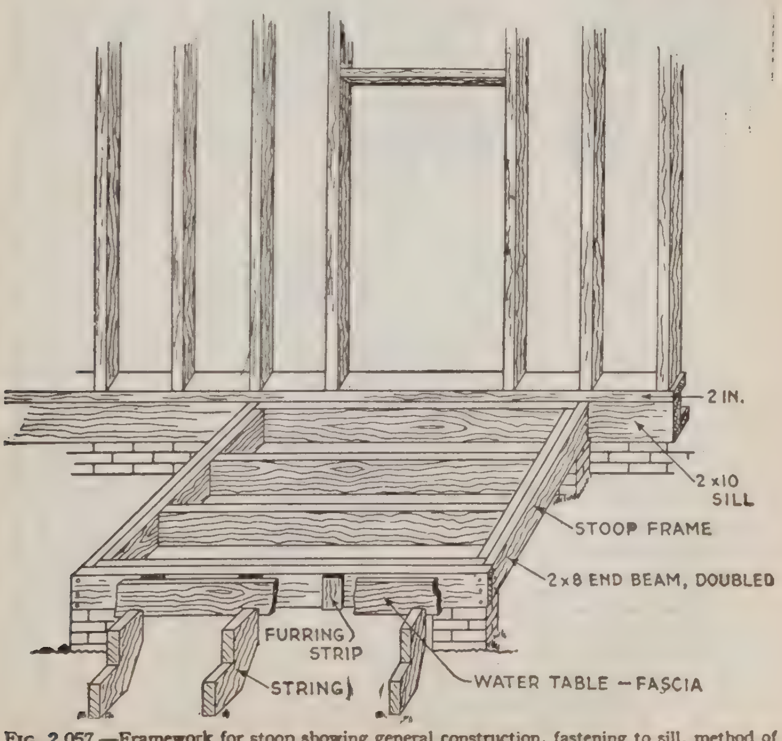
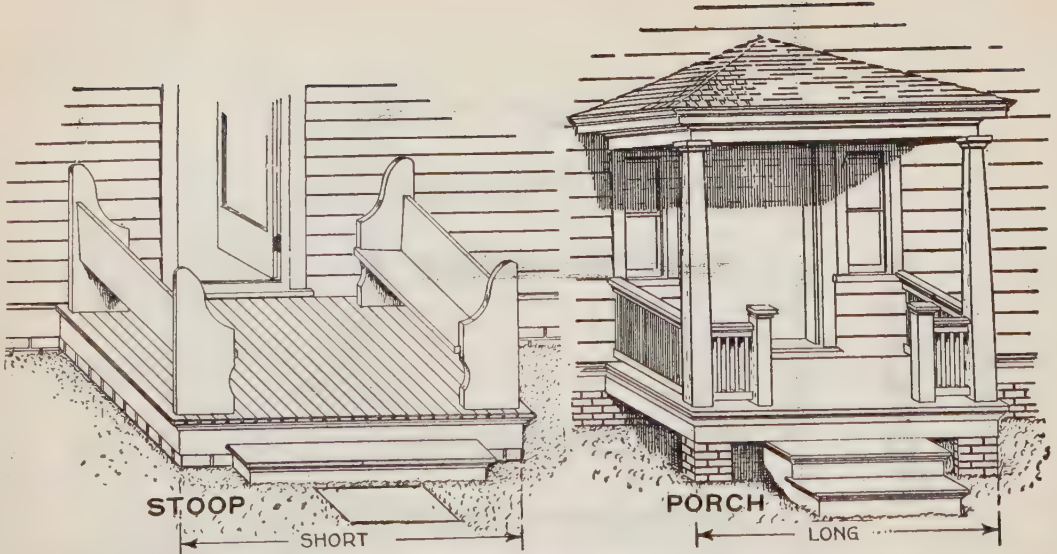


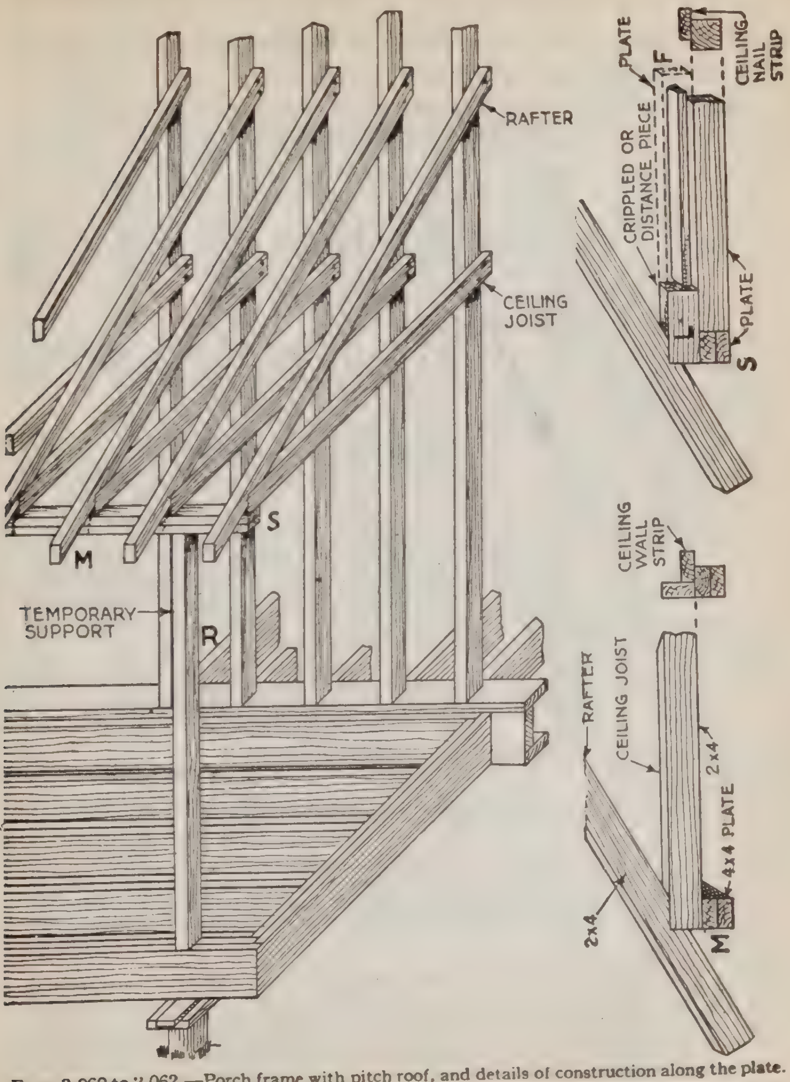
FIG. 2,057.—Framework for stoop showing general construction, fastening to sill, method of placing water table against framing strips for ventilation, etc.



FIGS. 2,058 and 2,059.—Distinction between a "stoop" and a "porch"—note carefully the distinction and avoid the inexcusable practice of using the wrong word.

without distinction to mean *a covered structure forming an outside entrance to a building.*

A careful distinction should be made between these terms and the word *stoop* which means *an uncovered platform at the door of a house, having usually steps with baluster guards and sometimes seats at the sides.* A stoop is virtually *a primitive*



FIGS. 2,060 to 2,062.—Porch frame with pitch roof, and details of construction along the plate.

porch without a cover, however the objectionable practice of using the term stoop for porch is inexcusable.

Since a stoop represents the simplest kind of entrance construction it may be properly considered here before treating of porches.

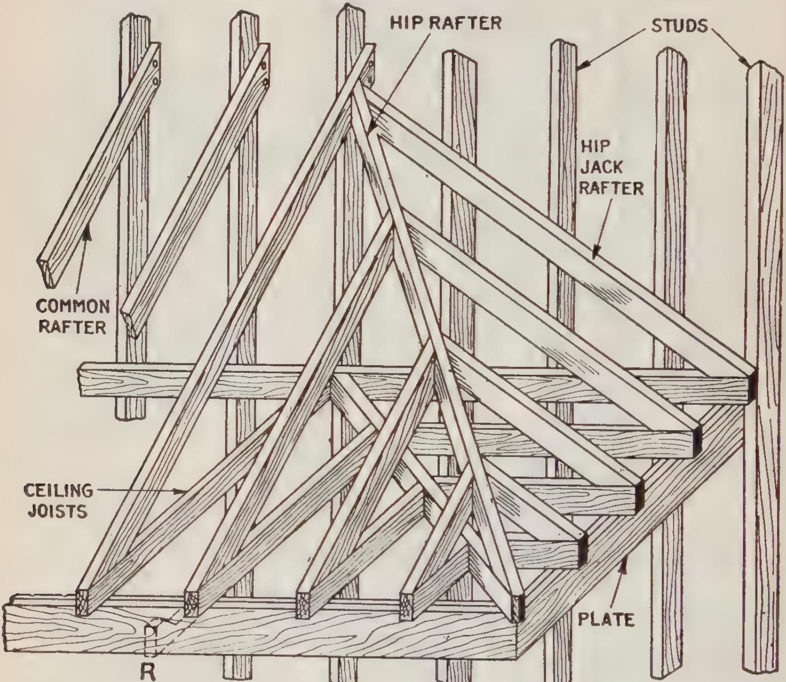


FIG. 2,063.—Hip roof frame for porch. The rafters and ceiling joists may come almost flush with plate as here illustrated, when necessary to get sufficient pitch, or may project beyond the plate as indicated by dotted lines at R. Where cramped for vertical space, more pitch can be obtained with the almost flush construction as must be evident.

FIGS. 2,060 to 2,062.—*Continued*.

At S, in order to keep the plate at the same elevation as at M, a block or short length of ceiling joist L, is inserted as shown forming a lift or distance piece—it is virtually a crippled or interrupted ceiling joist being cut from the same stock as the other ceiling joists. Sometimes this is continued across to the stud the same as the other joists as indicated by the dotted lines F, but with a plate of adequate cross section is evidently a waste of lumber. The temporary support R, saves the ornamental columns from injury during construction.

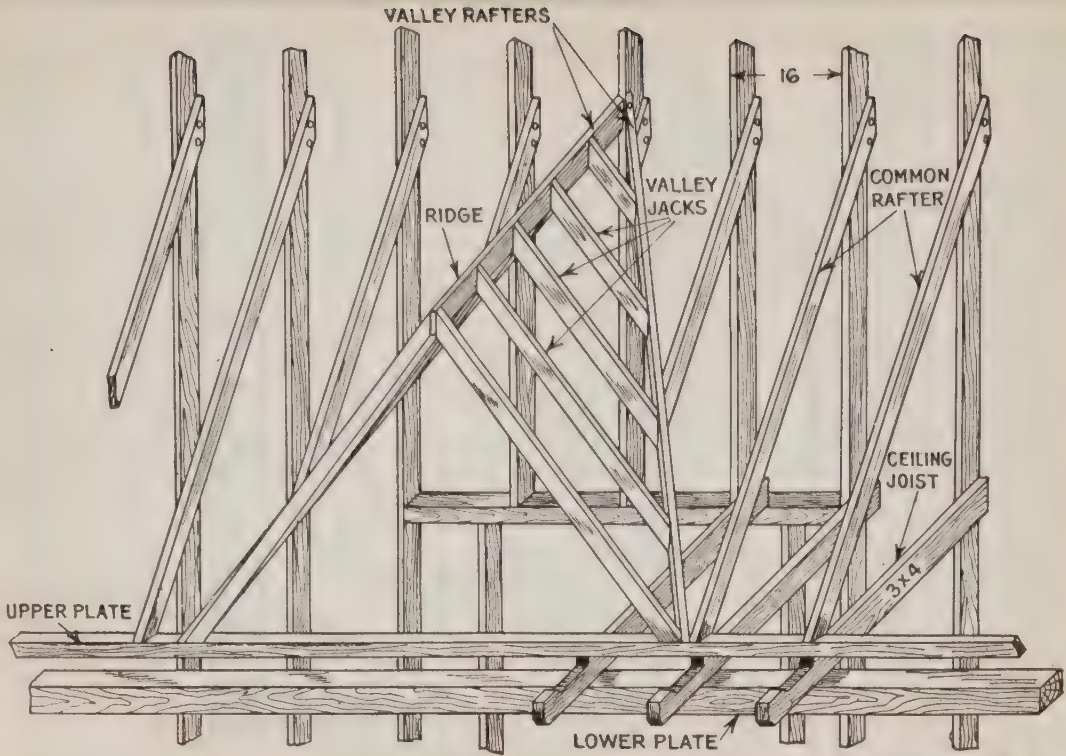
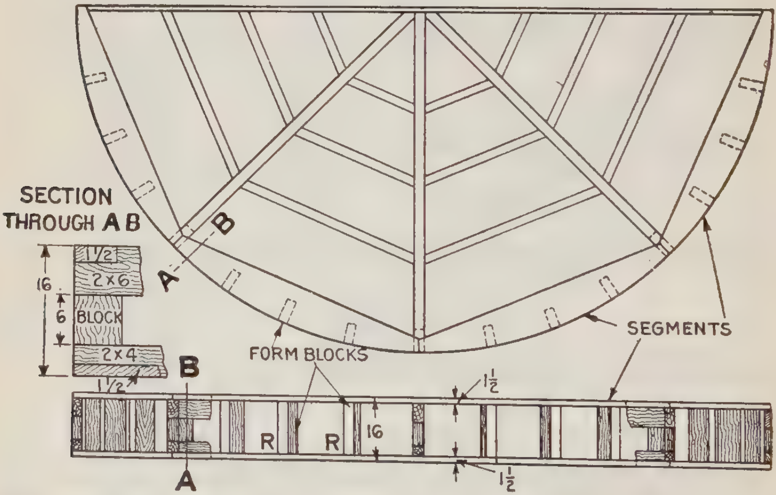


FIG. 2,064.—Valley roof frame for porch with flush rafters. The plate is divided into an upper and lower section, the upper plate raising the rafters so as to give sufficient depth of gutter without cutting away the ceiling joists too much.

Fig. 2,057 shows framework of stoop. The pitch from doorway toward steps should be sufficient to allow water to run off easily. Various values for pitch are given ranging from 1 in. in 10 ft. to 1 in. in 5 ft.

The joists are framed parallel with the sill. This brings the floor boards parallel to the direction of the pitch so that any water lying in the joints between boards will drain off. Ventilation is important in the prevention of decay, hence it is desirable where possible to use open construction such as lattice work on the sides permitting free circulation of air. In this connection the water table is not nailed directly against the stoop frame but is furred out about ¼ in. to allow any dampness to escape.

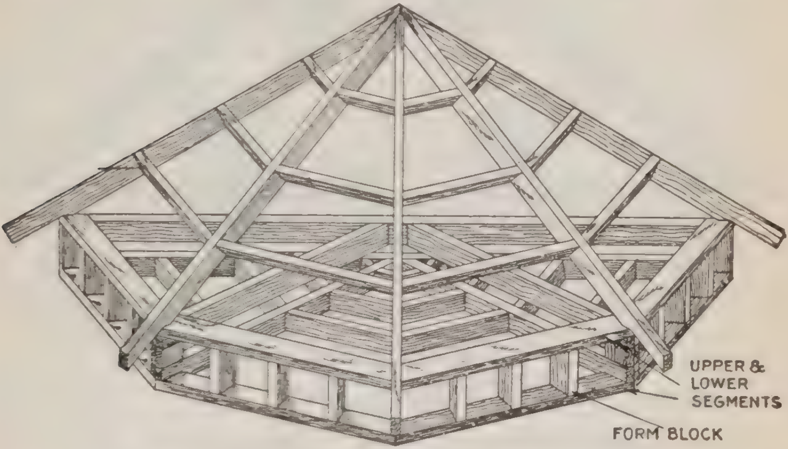
A simple porch frame with pitch roof is shown in figs. 2,060 to 2,062.

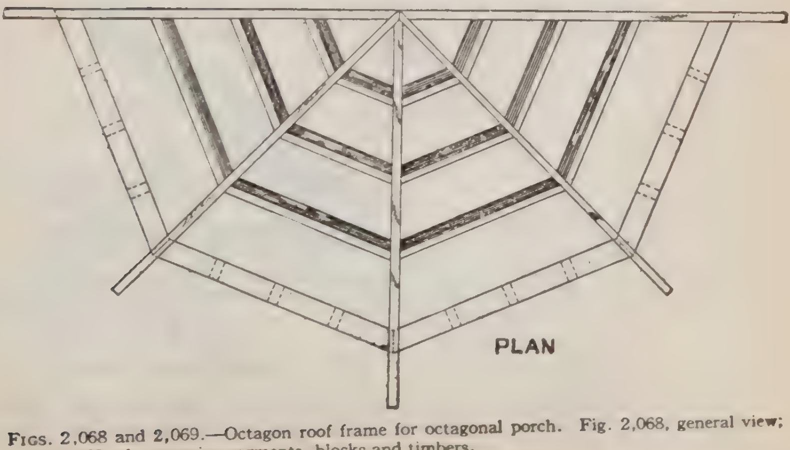


FIGS. 2,065 to 2,067.—Floor frame for circular porch. Fig. 2,065, plan; fig. 2,066, sectional view through AB; fig. 2,067, elevation.

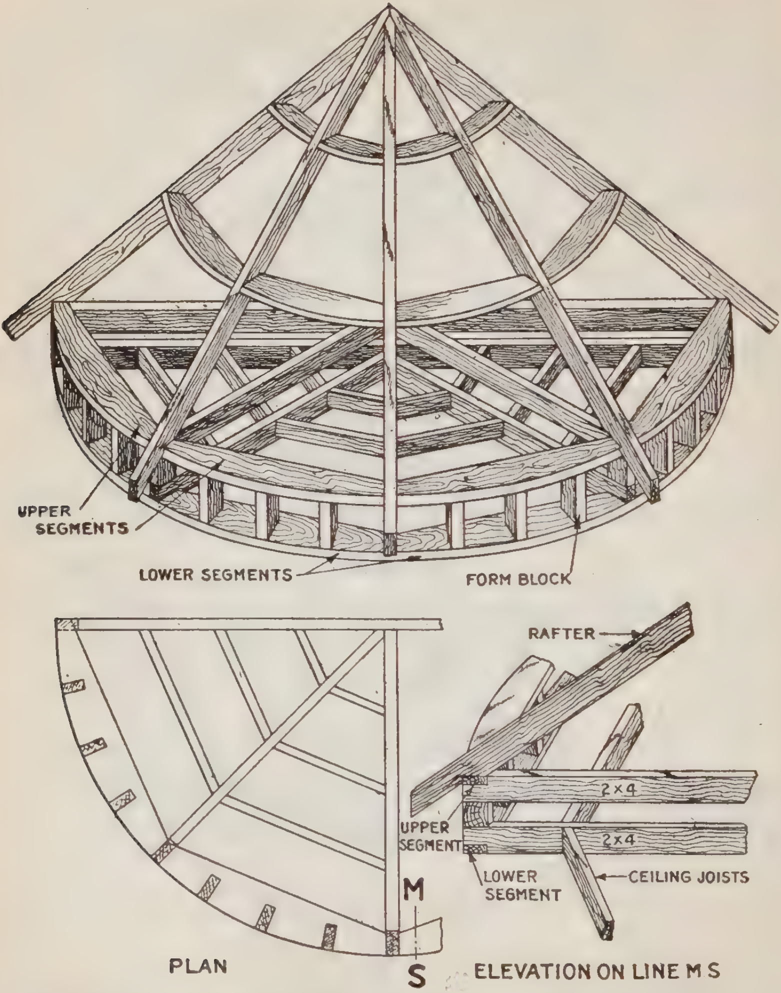
In general the height of a porch ceiling should not be less than 8 ft. to avoid exclusion of too much light. The pitch will usually

decide the height and it should not be made less than 5 ins. per ft. run. If sufficient ceiling height cannot be obtained with this pitch a less pitch may be given if a metal roof be used. Instead





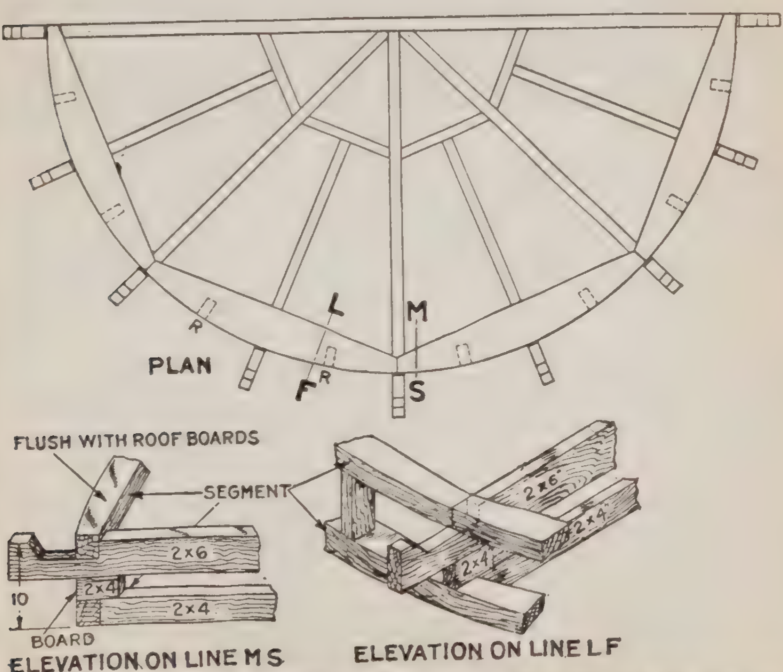
FIGS. 2,068 and 2,069.—Octagon roof frame for octagonal porch. Fig. 2,068, general view; fig. 2,069, plan showing segments, blocks and timbers.



FIGS. 2,070 to 2,072.—Conical roof frame for circular porch. Fig. 2,070, general view; fig. 2,071, plan, shows segmental base without rafters; fig. 2,072, sectional view showing built up construction at MS.

of the plain (common rafter) roof, the porch may be covered with a hip roof as in fig. 2,063, or valley roof, as in fig. 2,064.

The framework for a circular porch is shown in figs. 2,065 to 2,067. In the floor frame, figs. 2,065 and 2,066, there are two sets of segments, one flush with the top edge, and the other with the bottom edge of the joists. Numerous blocks as R, R well nailed flush between the segments makes a good form for the soffits. The roof framework, figs. 2,073 to 2,075, is built up to secure greater depth and provide for tail rafters which carry the gutter.



Figs. 2,073 to 2,075.—Flat roof frame for circular porch. Fig. 2,073, plan; figs. 2,074 and 2,075, detail elevation sectional views showing built up construction at MS and LF.

Points on Porches.—In the design and construction of porches it will be well to follow the suggestions here given:

Floor joists of a porch should run parallel with the side of the house.

Allow sufficient pitch to secure proper drainage.

Porch floor boards should not be over 4 ins. wide and must be laid open about 1⅛ in. to assist in ventilation under the porch.

Leave porch open underneath or use open lattice work to secure proper ventilation.

To prevent snow driving under the door make porch one step lower than the floor of the house.

The height of porch ceiling should not be less than 8 ft.

Metal roofing should be used where the pitch is less than 5 ins. in 12 ft.

CHAPTER 45

Scaffolding and Staging

By definitions, a scaffold or scaffolding is *a platform built against the side of a building, steeple, or the like for the support of workmen*, and staging is *an **elevated** platform built against the side of a building for the same purpose.*

That is, a scaffold is a one story structure serving to support workmen on a low building, whereas, staging is a more substantial structure progressively built up as the erection of tall buildings proceed, the name staging being applied because it is built up in "stages" or one story at a time.

It is impossible for a man to do satisfactory work at a height greater than about five feet above the place whereon he stands, therefore some arrangement must be made whereby he can always stand in the same relation to a structure, as it rises above the ground. To this end, scaffolding, or staging, must be erected.

These structures of a more or less temporary character provide an elevated support or floor where work can be carried on and storage room for such materials and tools as are immediately required. Many accidents occur annually through faulty or incomplete scaffolding that should be more securely guarded against. Accordingly the design and construction of these structures should be done by experienced men and no attempt should be made to economize by the use of inferior lumber and by inadequate nailing.

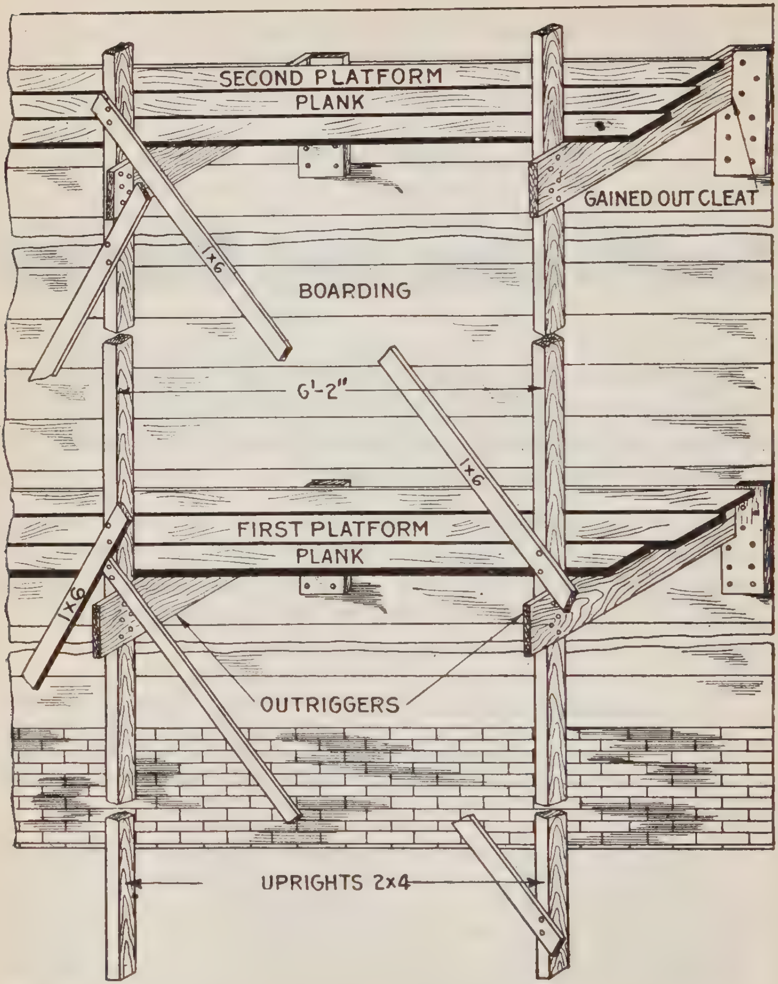


FIG. 2,076.—Simple scaffold built on side of wooden buildings and consisting of uprights, outriggers, cleats, and planks or *scaffold boards*, forming the platforms.

It is important that the lumber should be selected for straight grain and freedom from shakes or knots.

Green lumber should not be used because of inferior strength and hidden defects.

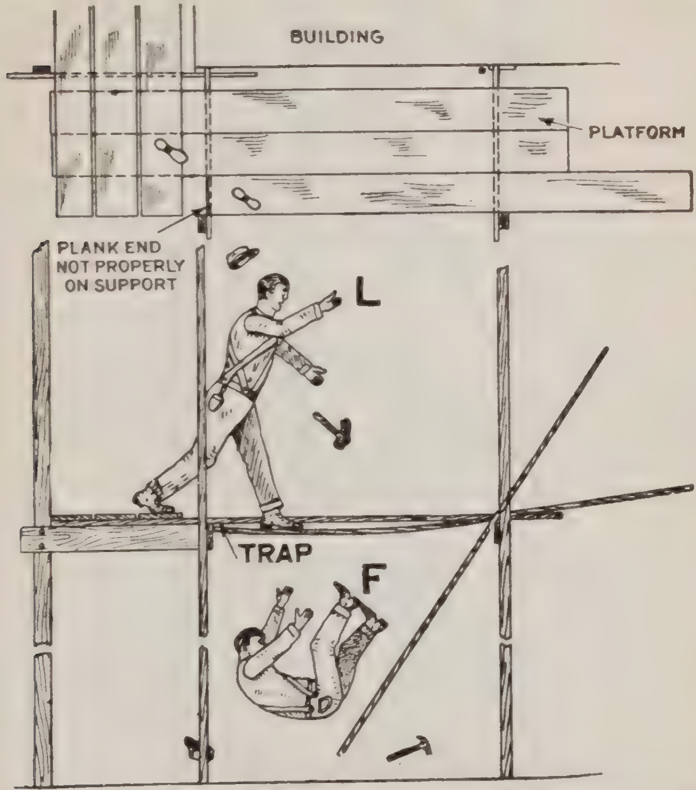


FIG. 2,077 and 2,078.—Trap formed by unsupported scaffold board. *In no case should the end of a scaffold board be unsupported for it may tip up when stepped upon, and cause a serious accident.* **L,** shows man stepping on board, and **F,** result.

1. Scaffolding

There is a great variety of scaffolds to meet the varied

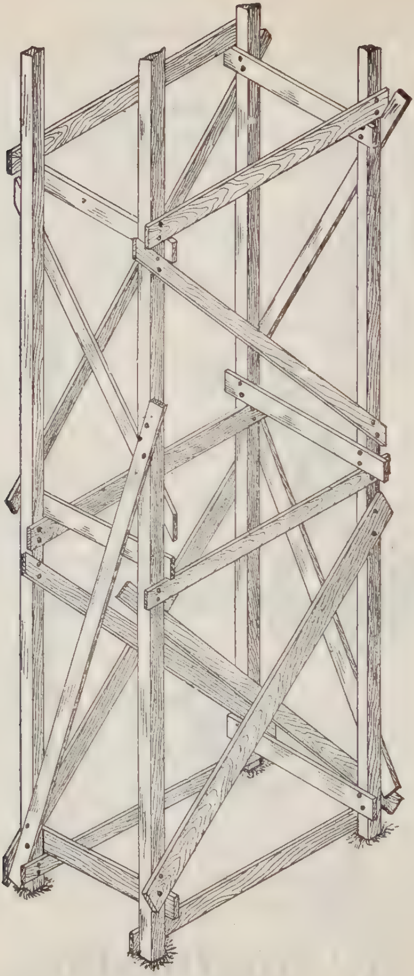


FIG. 2,079.—Detail of framed portable (supported) scaffold suitable for interior work on high ceilings, etc.

conditions encountered in building and in general with respect to the method of support, they may be classed as:

1. Supported.
2. Cantilever.
3. Bracket.
4. Suspended or hanging.

Supported Scaffolds.—A simple form of supported scaffold is shown in fig. 2,076, as used in the erection of wooden buildings. The scaffold as seen consists of uprights, outriggers, cleats and planks forming a platform. The various parts are fastened together, as shown.

Fig. 2,076 shows a typical two platform scaffold. Cleats are only used when there is no opening admitting of nailing outrigger to studding. These cleats are gained out and so placed as to come over a stud for sound nailing. The outrigger nailed into this notch. The uprights should be no less than 2 × 4″ and the brackets and cleats 1 × 6″ or 8″. Always cross brace with 1 × 2″ or like stripping, from the house to the uprights to prevent possible lateral movement. Good judgment will show that these need only be occasional.

The distance apart of supports is decided by the thickness or strength of planks that are to be used. A good mechanic, alert to efficient methods, will always have regular 1¼″ × 10 or 12″ spruce planks with ends protected by metal strips, exclusively for scaffolding. For these the distance apart can safely be, for all ordinary working purposes 8 to 10 feet. Ordinarily, however, the stock on the job that can be used for this purpose is ⅞″ boards and should be doubled on brackets set about 6 feet apart.

Where there are more than two platform levels requiring more substantial construction, and each upright consisting of more than one length, the structure *becomes a staging as distinguished rom a scaffold.*

Framed Portable Supported Scaffolds.—Frequently as in the repair or decoration of ceilings in churches and other public

buildings a self-contained portable scaffold which may be easily moved is required. A form of such construction consisting of four uprights, cross and diagonal braces is shown in fig. 2,079.

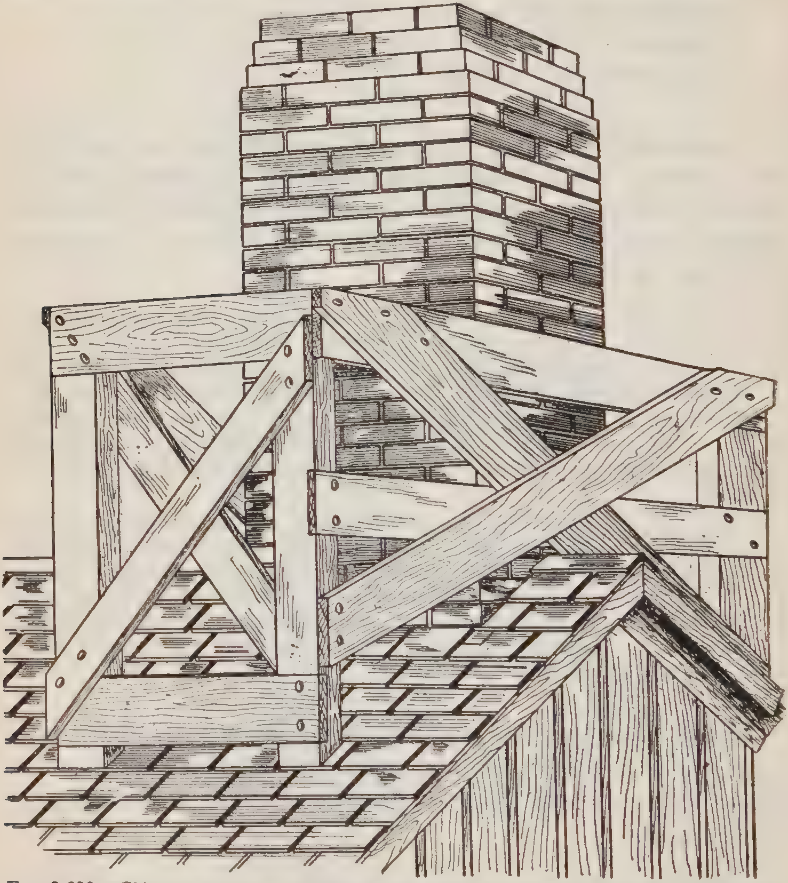


FIG. 2,080.—Chimney scaffold. ***As shown*** the scaffold is designed to straddle the roof ridge but may be made to fit one side by extending braces up to fasten over the ridge, or a cleat along the lower side. Its sections may be made on the ground and joined on the roof, working from ladders. It is obvious that it may be made any height.

This frame structure may be adapted to outside work by somewhat heavier construction.

Cantilever Scaffolds.—In this type of scaffold the platform is supported by beams which project through openings in the wall frame, resting on window sills or other horizontal mem-

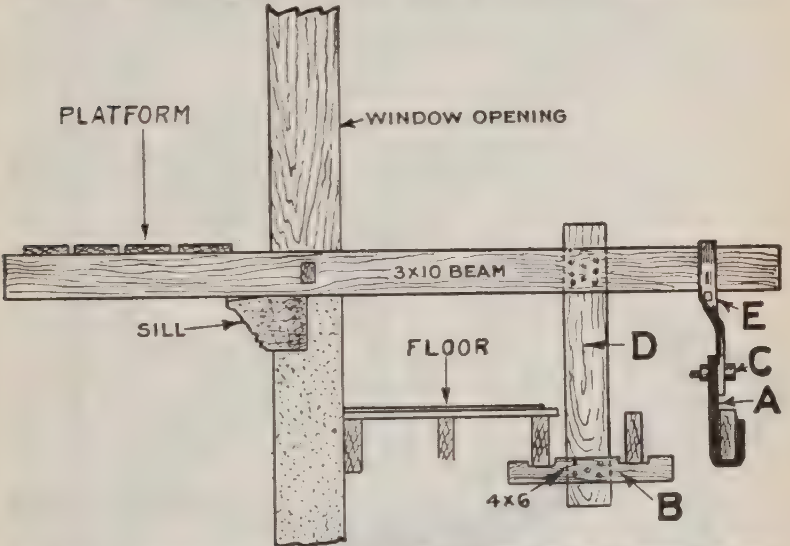
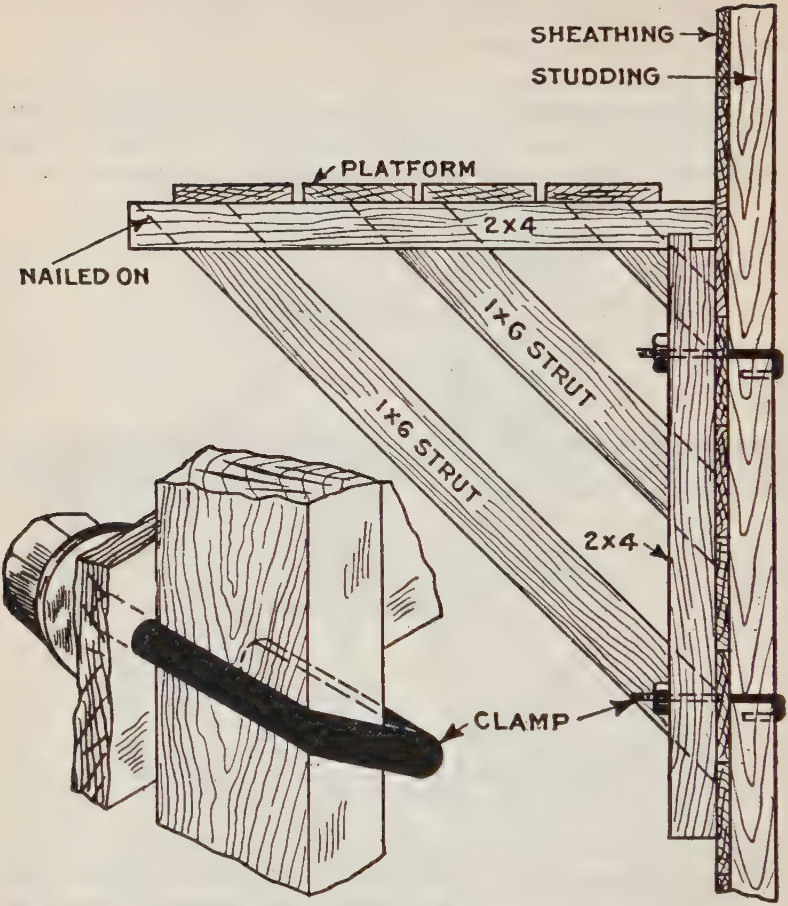


FIG. 2,081.—Cantilever scaffold supported on sill and with beam ends fastened to joists. A, iron strap method; DB, saddle method. The iron strap is adjustable for length by the bolt C, which may engage in any of several holes drilled in the strap E.

bers, with the inner ends secured as shown in fig. 2,081. These ends may be secured by hook irons as at A, passing around one joist, or by a vertical wooden piece D, attached to the beam and to a saddle B, engaging with two joists as shown.

Bracket Scaffolds.—This is a cheap and convenient form of scaffold which requires little lumber and it is semi-portable, that



FIGS. 2,082 and 2,083.—Bracket scaffold. ***In construction***, the horizontal and vertical members of the brackets are made of 2 × 4 scantling with 1 × 6 struts. Each bracket requires two 2 × 4 pieces 4 ft. long, two 1 × 6 pieces 3 ft. long, and two 1 × 6 pieces 5½ ft. long. These are assembled as shown in the figure. In addition there must be provided for each bracket two hook bolts for attaching the bracket to the side of the building. The local blacksmith can easily fashion these hook bolts. The hook bolts are so arranged that they may be clamped to the studding, thus giving a very large measure of security. If due care be taken to have these hook bolts of ample length they may be accommodated to either 4 in.

is, it can be moved from one position to another by removing the bolts which fasten it to the wall frame.

As shown in fig. 2,082, the bracket has two studs running between the horizontal and vertical members, with two hook bolts arranged to pass around a stud and through the sheathing. Another form of bracket scaffold, designed to be supported on window sills, or horizontal members of the wall frame is shown in fig. 2,084.

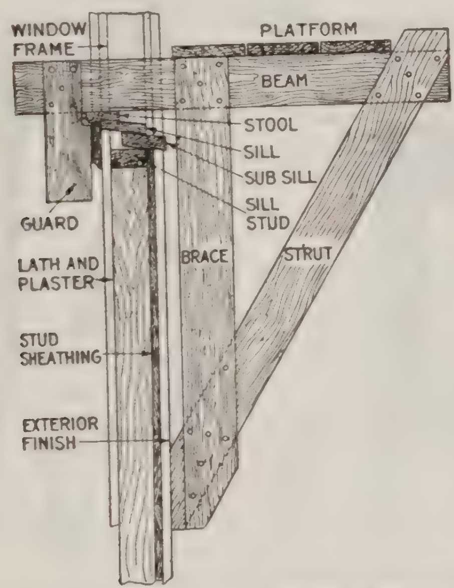


FIG. 2,084.—Window form of bracket scaffold. ***As shown,*** the platform beam is supported by the window sill and the strut whose lower end presses against the sheathing.

FIGS. 2,082 and 2,083.—*Text continued.*
or 6 in. studding. They may safely be made of rod iron ½ in. in diameter. ***In placing,*** the bracket holes are bored through the sheeting at proper places to receive the bolt guards. The hook end of the latter are made to grip the studding tightly while the other end is passed through holes in the vertical piece of the bracket. When the nut is tightened the scaffold is drawn tightly to the walls of the building. It is then in the proper position to receive its load. A large washer should be provided with each bolt to prevent the nut digging in the wood. Fig. 2,083 shows detail of the hook bolt which fits around the stud.

Suspended or Hanging Scaffolds.—This form of scaffold is generally employed by painters and in erecting for cornice work. The simplest is the ladder scaffold consisting of planks laid on the rungs of a ladder forming a platform suspended by two double iron hooks fastened to block and fall rigging as shown in fig. 2,085.

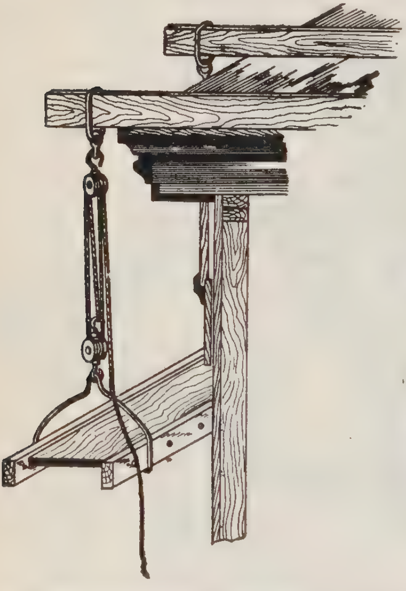


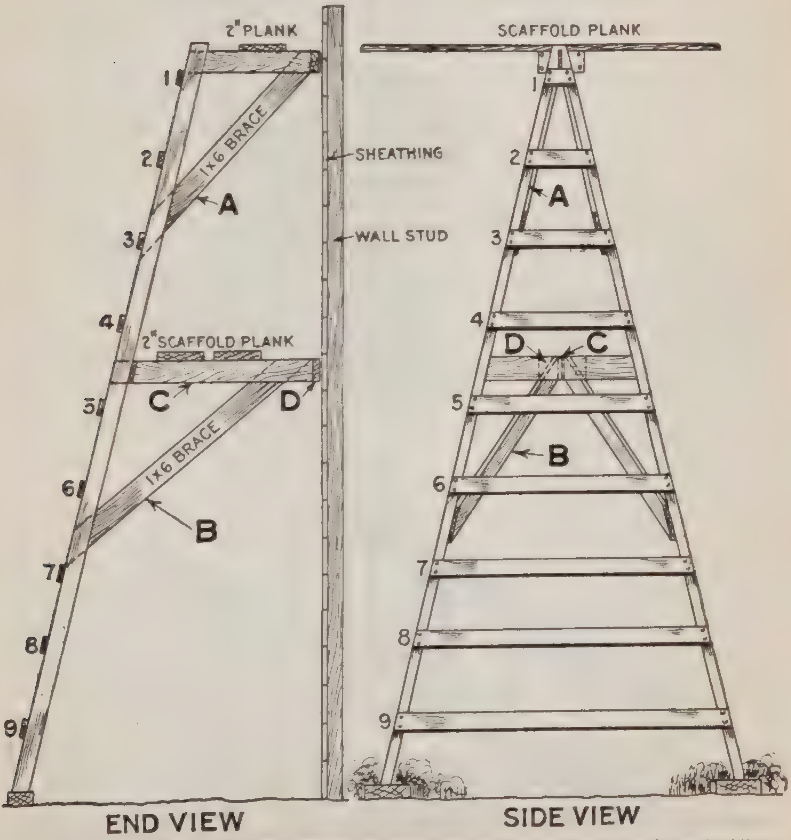
FIG. 2,085.—Ladder form of suspended or hanging scaffold.

FIG. 2,086.—Suspended seat with block and fall; a convenient one man rig for small repairs or for painting.

2. Staging

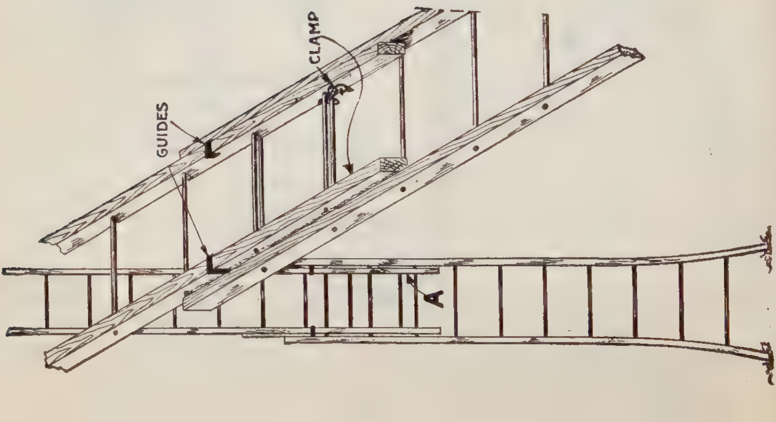
In tall buildings, it is evident that some type of construction heavier and stronger than ordinary scaffolding must be

employed; a construction permitting vertical additions as the building rises story by story. Such a construction is known as a *staging*, as distinguished from a scaffold, presumably because it



FIGS. 2,087 and 2,088.—Portable scaffold for sheathing, siding, and painting frame buildings. Fig. 2,087, end view; fig. 2,088, side view A, B, struts; C, platform beam; D, end piece; 1 to 9, steps.

FIG. 2,089.—Extension ladder, of two or more sections. ***In construction***, the sections are arranged to telescope each other through iron guides. At the point A, is placed an automatic clamp that is easily released by a slight lift and is locked by downward pressure.



is erected in successive stages as the construction of the building progresses.

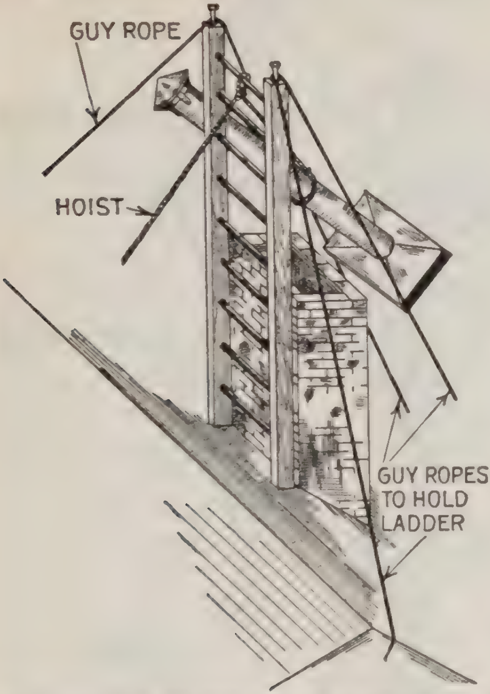


FIG. 2,090.—Guyed ladder rig for raising a flue extension, a convenient method on a steep roof. The rig is placed thus: Put the lower end of a ladder on the roof behind the flue on the high side, having a board beneath the feet of the ladder if necessary to keep the ladder from making a hole in the valley or chimney flashing. Tie the ladder securely to the chimney with a rope. Fasten a pulley to the top of the ladder as shown in the illustration and run a rope through the pulley, tying one end to the flue top, a little above the center of balance. Now connect four guy ropes to the top of the end of ladder and secure these ropes so as to make the ladder rigid and safe and to take the strain off of the chimney. Then the flue top can be pulled up from the ground and a man can go up the ladder and set it in place. Then he can fasten the guy wires attached to the chimney top so that their lowere end can be secured at convenient places. The ladder may then be removed and the job is done. Care should be taken to make the flue top large enough to slip on to the brick chimney without any difficulty as it will not be an easy matter to adjust it or work with it from the ladder at such a height.

A typical staging is shown in fig. 2,091. Aside from its use in the construction of tall buildings, staging is also largely employed in bridge and viaduct construction. In such cases the staging is generally about the height of the springing of the arch and is used to support the center, or as a platform to connect the different sections of girders, etc.

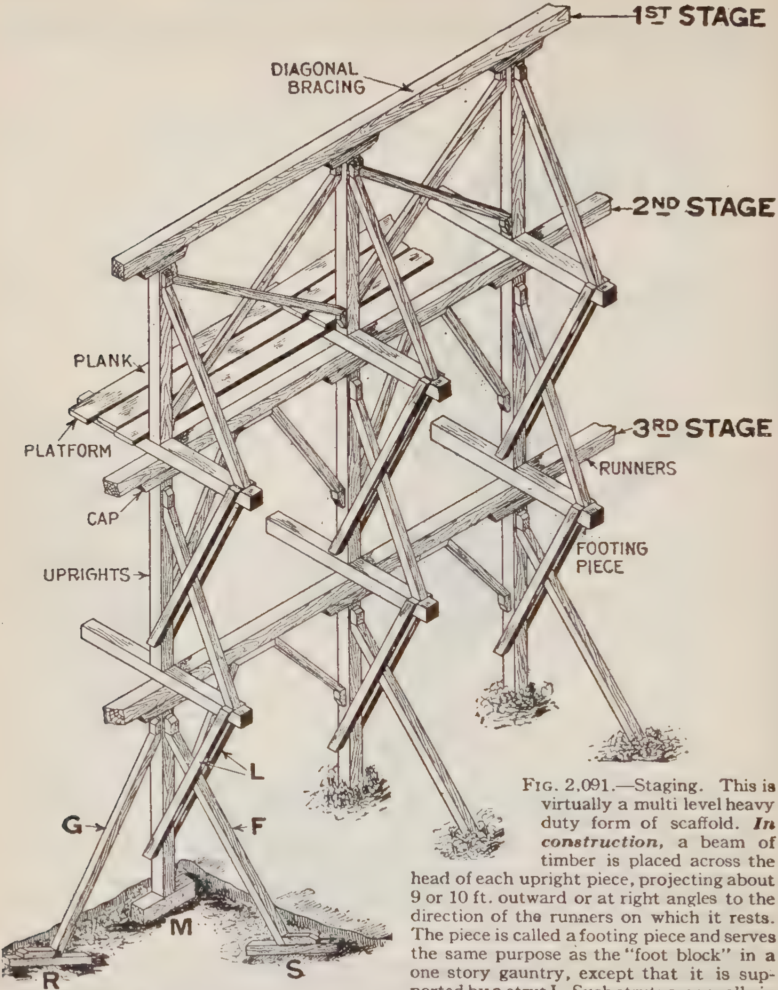


FIG. 2,091.—Staging. This is virtually a multi level heavy duty form of scaffold. ***In construction,*** a beam of timber is placed across the head of each upright piece, projecting about 9 or 10 ft. outward or at right angles to the direction of the runners on which it rests. The piece is called a footing piece and serves the same purpose as the "foot block" in a one story gauntry, except that it is supported by a strut L. Such struts are usually in two pieces in order that a strut F, may pass between them. The uprights of the upper tiers should always be placed over those of the lower to prevent cross strain in the horizontal members. Diagonal bracing is frequently employed in the upper tiers as shown. In erecting, a firm footing should be provided for the lower uprights and struts F and G, by suitable blocks as R, M, S.

CHAPTER 46

Hoisting Apparatus

The term hoist is defined as *a machine for raising or lowering heavy or bulky articles.* In the construction of buildings some form of hoist is almost always necessary, as for instance in placing heavy girders, sections of wall frames, roof trusses, etc. In any hoist means must be provided for attaching the load, an elevated purchase or support for the lifting rigging, and proper reduction gearing between the load and point at which the power is applied, depending upon the intensity of the applied force. The various forms of hoist used by builders may be classified:

1. With respect to the lifting medium, as:

   a. Rope
   b. Chain

2. With respect to the form of gearing, as:

   a. Pulley (block and fall)
   b. Differential
   c. Spur gear and drum
   d. Spur gear and spool

3. With respect to the supporting structure, as:

   a. Gin pole

b. Tripod or shear legs; *c*. Stiff leg mast; *d*. Derrick, etc.

4. With respect to the drive, as:

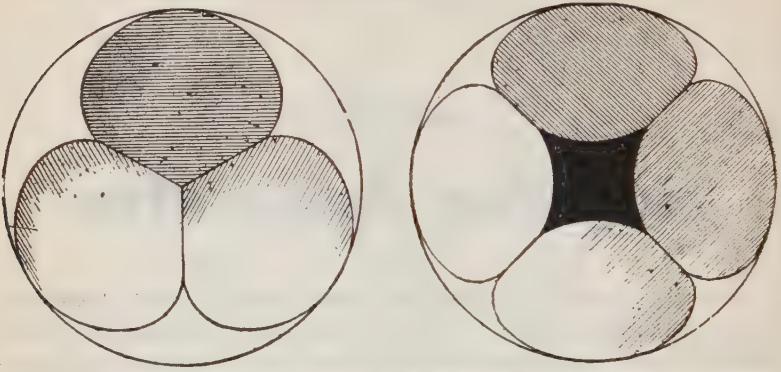
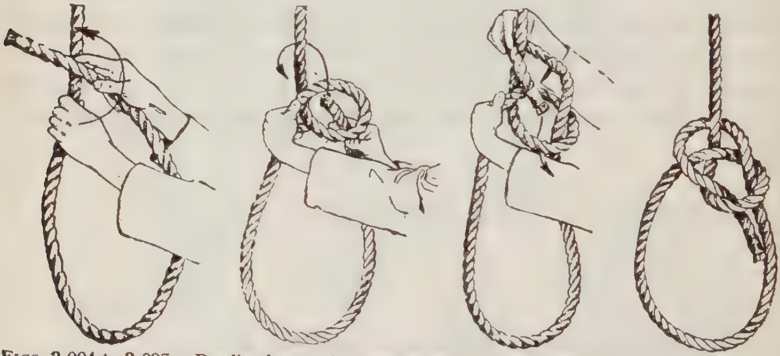


FIG. 2,092 and 2,093.—End view of three and four strand ropes of the same size, a circle having been drawn about each in order that their solidness may be compared. The black center section in fig. 2,093 is a core.

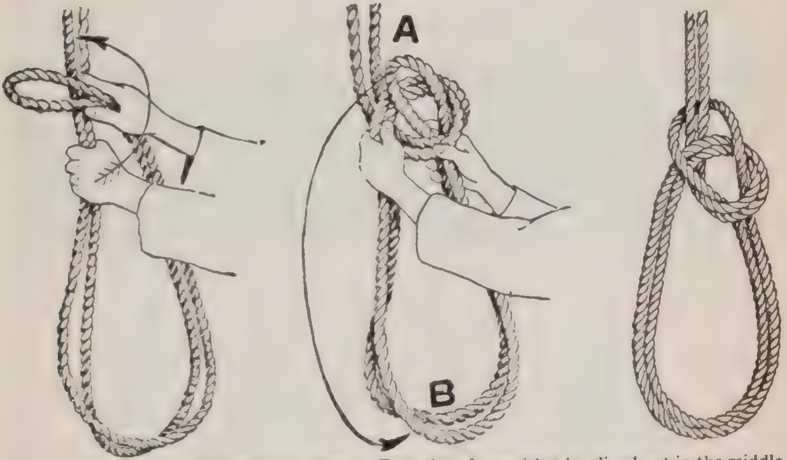


FIGS. 2,094 to 2,097.—Bowline knot. *I. Overhand method.* With the right hand lay the end of the rope over the long rope, and with the left hand grasp the long rope below the crossing, as in fig. 2,094. Hold the right hand stationary, and with the left hand bring the long rope up and over to form a loop about the end, as indicated by the arrow in fig. 2,094 and as shown in fig. 2,095. With the right hand draw the end up through the loop and pass it around behind the long rope from right to left, as indicated by the arrow in fig. 2,095 and as shown in fig. 2,096. Pass the end forward and down into the loop again from above as indicated by the arrow in fig. 2,096 and as shown in fig. 2,097. Note that this knot consists of a loop with a bight up through it, the bight going around behind the long rope. The bowline knot is the best knot known for forming a loop that will not slip under strain and that may be easily untied. The overhand method is used when standing opposite the end of a slack rope and making a loop that is not fastened to any object.

a. Hand
b. Steam
c. Electric
etc.

1. The Lifting Medium

Ropes.—Hemp, cotton, or wire is used in the manufacture of ropes. *Hemp is stronger and more durable than cotton and is



FIGS. 2,098 to 2,100.—Bowline on a bight. To make a loop with a bowline knot in the middle of a long rope, or to get a loop of double rope at the end of a rope, a bowling knot is tied by the overhand method, using a bight of the rope instead of a single rope. The steps indicated in fig. 2,098 are the same as those described for fig. 2,094. After arriving at the position shown in fig. 2,099, however, the knot is made differently. Instead of bight A, being passed around behind the long ropes, it is pulled up through the small loop and then brought downward, as indicated by the arrow in fig. 2,099, and the whole of the large loop B, is passed through the bight A. The bight is then brought back to its starting point and loop B, is pulled out again, which brings bight A, down into place and produces the finished knot as shown in fig. 2,100.

NOTE.—Of late years the supply of true hemp has been insufficient to meet the demand, and a substitute has been found in the outer fibre of the leaves of the banana plant grown in the Philippine Islands. The prepared fibre is exported from the city of Manila under the name of "Manila hemp," the rope made from it being known as manila rope.

FIGS. 2,101 to 2,103.—Bowline knot. ***II. Underhand method.*** Pass the rope through the eye or around the object from left to right, holding the long rope in the left hand. Take a half hitch around the long rope, starting it by passing the end across over the long rope (see fig. 2,101). Now transfer the loop from the short rope to the long rope. This is done by giving slack with the left hand, and pulling up with the right, as indicated by arrows in fig. 2,101. With the loop transferred to the long rope and the end passing through it, as in fig. 2,102, it is necessary only to bring the end from left to right under the long rope, as indicated by the arrow in fig. 2,102, and back into the loop from below, as shown in fig. 2,103. The knot is now ready to be tightened up, when it will be finished. The underhand method is used when standing alongside the rope and making a loop around some object or through an eye.

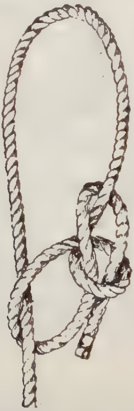
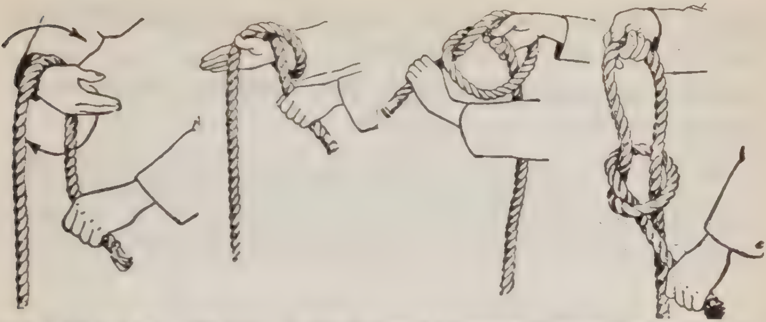
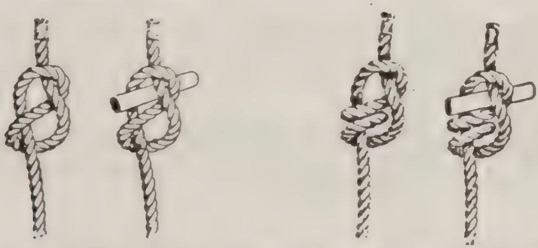


FIG. 2,104.—Running bowline. This is simply a slip knot wherein the loop through which the rope slips is formed by using the bowline knot, as already described.



FIGS. 2,105 to 2,108.—Slip knot. It may be made by starting either with the position shown in fig. 2,105 or with that in fig. 2,107, whichever be easier for the person tying the loop. When beginning with fig. 2,105, grasp the end of the rope in the left hand and, bringing the right hand upward, pick up a bight of the rope on the wrist as shown. Bend the right wrist so that the palm of the hand is upward and the little finger touches the short end of the rope. Then rotate the wrist as shown by the upper arrow. This will cross the sides of the bight and form a loop around the wrist, and at the same time will bring the main rope in between the thumb and the first finger as shown in fig. 2,106 and as indicated by the lower arrow in fig. 2,105. Grasp the main rope and draw a bight up through the loop, as shown in figs. 2,107 and 2,018. In starting with the position shown in fig. 2,107, the end is held in the left hand and the loop formed by twirling the rope to the right between the thumb and the fingers of the right hand Either method is easy, provided the end is held in the left hand at the beginning.



FIGS. 2,109 and 2,110.—Figure eight knot. This is used for making a knob on the end of a rope or for keeping the strands from untwisting. It may be easily untied. Form a bight near the end of the rope, give the short end one complete turn about the long rope, and past it up into the bight (fig. 2,109). Pull up tightly, so that the end is square across the rope. By putting in a short stick, or shackle, as shown in fig. 2,110, the knot may be very easily untied.

FIGS. 2,111 and 2,112.—Stevedore's knot. This knot is used for making an extra large knob on the end of a rope. It is tied the same as a figure-eight knot, except that two turns are taken around the rope instead of one, and it may be made either without or with a shackle as in fig. 2,111 and in fig. 2,112.

used for light duty hoisting as with block and tackle, wire rope being used for heavy duty hoisting.

Rope is manufactured three or four strand as shown in figs. 2,092 and 2,093.

In the three strand rope, the strands are larger than in the four strand rope, the four strand being stronger and more pliable, has a nearer even surface, weighs more per foot, and being constructed on a core, the strands are kept away from the center, thus reducing chafing as the rope is bent around a pulley.

FIG. 2,113.—Half-hitch. This is a temporary and not very secure fastening. In the figure the half-hitch is shown taken around the main rope and, as shown, it consists merely of a loop around the rope with the free end pinched between the rope and the object to which it is attached.

FIG. 2,114.—Timber-hitch. This is a secure temporary fastening very easily undone, which is used to a considerable extent by carpenters for raising timbers. ***To make,*** pass the rope around the timber, take a half-hitch around the rope, and then pass the free end once more between the rope and the timber, as shown.

FIGS. 2,115 and 2,116.—Two half-hitches. Fig. 2,115, ***wrong*** way; fig. 2,116, ***right*** way. This is a good fastening and is secure provided it is well pulled down and set before being subjected to a load. If tied according to fig. 2,116, the hitches are easily loosened, but if made as shown in fig. 2,115, they will jam tightly.

The extra cost of the four strand rope is justified if the rope be properly cared for. When a weight is hung upon the end of a rope the tendency is for the rope to untwist and become longer.

In making a rope it is impossible to make these strains exactly balance each other. It is this fact that makes it necessary to take out the "turns" in a new rope, that is, untwist it when it is at work. The amount of twist that should be put in the yarns has been ascertained approximately by experience.

In the following table the figures refer to average grade Manila rope, new and *without knots*.

Wire rope, if made flexible, that is, with a hemp core to each strand and a central hemp core to the rope itself as well ropes will stand a strain in lbs. approximately equal to the square of the circumference in inches multiplied by 600.

Thus, a wire rope termed "three-quarters," that is, with a diameter of about ¾ inch and a circumference of 2¼ inches.

Properties of Three Strand Manila Rope

I	II	III	IV		V	VI	VII
Diameter (Inches)	Circumference (Inches)	Weight of 100 feet of rope (Pounds)	Length of each pound of rope Ft.	Ins.	Safe load (Pounds)	Breaking load (Pounds)*	Diameter of pulley (Inches)
3/16	9/16	2	50	0	35	230	1 1/2
1/4	3/4	3	33	4	55	400	2
5/16	1	4	25	0	90	630	2 1/2
3/8	1 1/8	5	20	0	130	900	3
7/16	1 1/4	6	16	8	175	1,240	3 1/2
1/2	1 1/2	7 2/3	13	0	230	1,620	4
5/8	2	13 1/3	7	6	410	2,880	5
3/4	2 1/4	16 1/3	6	1	520	3,640	6
7/8	2 3/4	23 2/3	4	3	775	5,440	7
1	3	28 1/3	3	6	925	6,480	8
1 1/8	3 1/2	38	2	7	1,260	8,[illegible]20	9
1 1/4	3 3/4	45	2	2	1,445	10,120	10
1 3/8	4 1/4	58	1	8	1,855	13,000	11
1 1/2	4 1/2	65	1	6	2,085	14,600	12
1 3/4	5 1/4	97	1	0	3,070	21,500	14
2	6	113	0	10	3,600	25,200	16
2 1/2	7 1/2	184	0	6½	5,630	39,400	20
3	9	262	0	4½	8,100	56,700	24

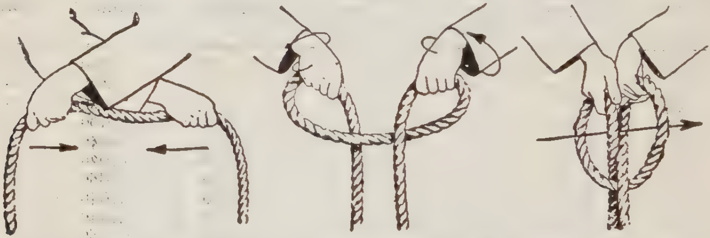
* From the rules by C. W. Hunt and Spencer Miller.

NOTE.—It should be noted that *knots weaken a rope*. The safe load given in the table is the greatest load that a single rope should carry, being about 1/7 of the breaking load. The data is from C. W. Hunt & Co.

will stand safely 3037.5 lbs., having then a factor of safety of seven.

Wire ropes need to be kept clean from rust, etc., and should be lubricated when running; graphite being as good as anything.

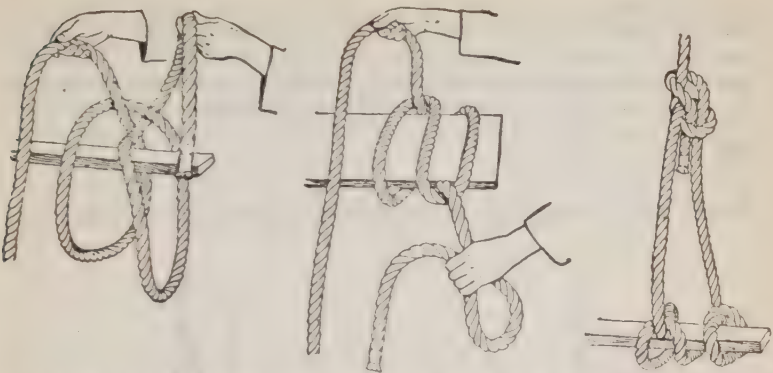
FIGS. 2,117 to 2,119.—Clove hitch. 3. ***Sailor's method:*** In this method the hitch is made while there is a pull on the rope, as in mooring a boat. Sustain the strain on the rope with the left hand, as shown in fig. 2,117, and by twisting the rope to the right with the right hand, as indicated by the arrow, form a loop in the rope and then roll the loop over the top of the post. Move the left hand up beyond the loop, hold the rope there, and with the right hand form a second loop and roll it in place as shown in fig. 2,118. Note that in the finished hitch, fig. 2,119, the diagonal rope binds both ends against the post.



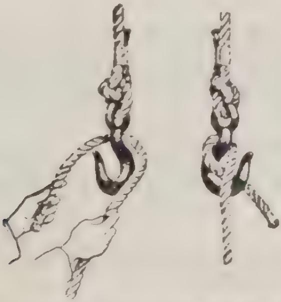
FIGS. 2,120 to 2,122.—Clove hitch. 4. ***Circus method:*** Cross the arms in front of the body, the left outside the right, and pick up the rope as shown in fig. 2,120. Without twisting the wrists uncross the arms, as indicated by the arrows in fig. 2,120 and take the position shown in fig. 2,121. Now rotate both hands to the right as indicated by the arrows around the wrists, and put the knuckles of the left hand into the palm of the right, as shown in fig. 5,982. Slip the loop from the left hand into the right, and the hitch is ready. For most persons these drawings will be more easily followed if they are inverted. The circus method is the quickest way of making the clove hitch, and should be learned by everyone. It is especially useful in pitching large tents, when many ropes must be picked up from the ground and fastened to short stakes.

Occasionally the rope should be carefully oiled with raw linseed oil, well rubbed in.

So called flexible wire ropes should *not be worked* around a sheave or drum



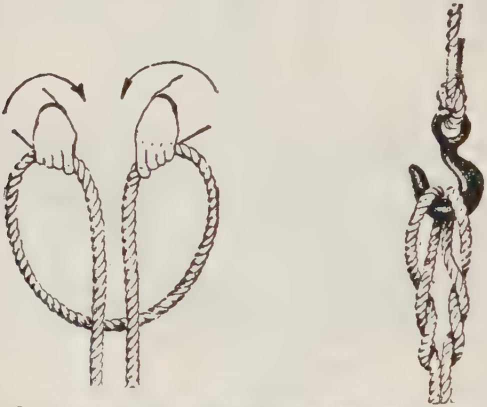
FIGS. 2,123 to 2,125.—Scaffold hitch. By the cowboy's or circus method form a clove hitch of ample size so that when placed over the end of the scaffold plank it will hang loosely below it, as in fig. 2,123. Draw to the left the rope in the left hand in fig. 2,123, and to the right the rope in the right hand in the same figure, thus gaining the position shown in fig. 2,124. Turn the plank over, draw the ropes up above it, join the short end to the long rope by an overhand bowline (fig. 2,214), pull the bowline tight, at the same time adjusting the length of the two ropes so that they hold the plank level, and the hitch is finished as shown in fig. 2,125. Attach a second rope to the other end of the plank in the same way and the scaffold is ready. Many occasions arise involving the need of a single board scaffold, hung by a single rope at each end. If a scaffold of this kind is to be safe, the ropes must be attached to the board in such a way that the board will not turn. The scaffold hitch fills the need.



FIGS. 2,126 and 2,127.—Blackwell hitch. Form a bight in the rope and pass it under and back of the hook, as shown. Cross the sides of the bight to form a loop about the shank of the hook, passing the free end between the hook and the main rope as in fig. 2,127. The Blackwell hitch is useful when it is necessary to attach a rope to a hook. A quick and secure temporary fastening is the Blackwell hitch, which is simply a half hitch about the shank of the hook.

having a less diameter than *six times the girth* of the rope; harder and stronger ropes, such as are used for winding from great depths, should not pass over any wheel of a less diameter than *ten times the girth*. The smaller figures are for ropes worked at a slow speed only; for each increase in speed the pulley should also be enlarged. This must specially be insisted upon with *elevators* and *lifts*, in which case it is advisable to exact *ten* as a minimum ratio.

Ropes and cordage are so peculiarly a sailor's province that



FIGS. 2,128 and 2,129.—Cat's paw. Form a bight in the rope, grasp the sides of the bight, as shown in fig. 2,128, thus forming two loops, twist each loop a full turn in the direction indicated by the arrows, and hang the loops on the hook as in fig. 2,129. The cat's paw provides a double rope where wear comes, and permits a load to be carried on either end of the rope.

nautical expressions must necessarily be used. Accordingly a few explanations will first be given of terms used in this connection:

Belay.—To make fast the end of a tackle fall, etc., at the conclusion of a hoisting operation or the like.

Bend.—A fastening of one rope to another or to a ring, thimble, etc.

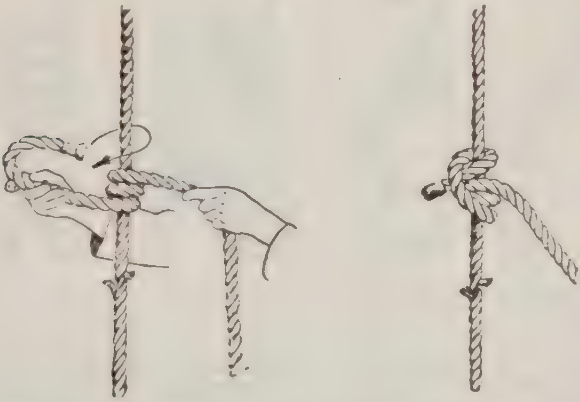
Bight.—The loose part of a rope between two fixed ends.

Haul.—To heave or pull on a rope.

Hitch.—A fastening of a rope simply by winding it, without knotting, around some object.

Knot.—A fastening of one part of a rope to another part of the same, by interlacing them and drawing the loops tight.

Lay.—To twist strands up together as in rope making, the fibre or tow receiving a right handed twist to make yarns, yarns being laid left handed into strands, and strands right handed into ropes. Three strands make a hawser, and three hawsers are laid up into a cable.



FIGS. 2,130 and 2,131.—Taut line or rolling hitch. Wrap the new rope two full turns around the taut one, progressing in a direction away from the load as in fig. 2,130. Pass the end up over the wrapping, draw it firmly, and take one or two half hitches about the taut rope between the wrapping and the load, as indicated by the arrow in fig. 2,130 and as shown in fig. 2,131. The hitch will not hold unless the wrapping and the half hitch are pulled up securely in the first place and are tightened as the strain is put on the new rope. The taut line hitch is useful on many occasions when it is necessary to attach a rope to another rope that is supporting a load and that therefore cannot be bent. For instance, if a strand break, a new rope must be attached to the rope above the break; or if in hauling with block and tackle on a rope to raise a load the tackle be pulled together without getting the load high enough, a new rope must be attached to the taut one near the load in order to support it temporarily and to allow the tackle to be extended and reattached to the pull rope farther up.

Make fast.—To secure the loose end of a rope to some fixed object.

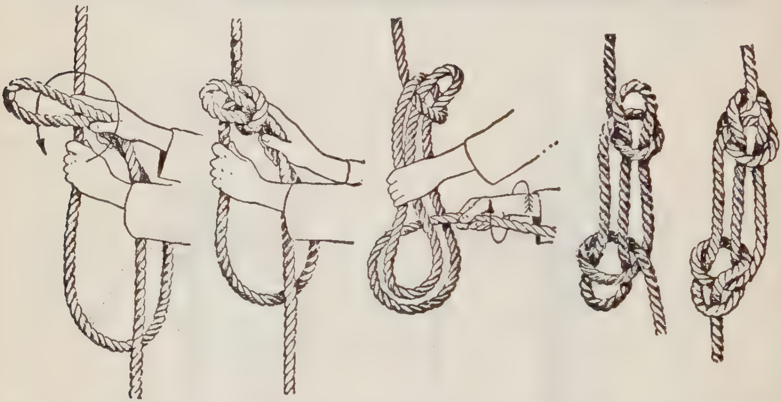
Marline spike.—A long tapered steel instrument used to unlay or separate the strands of rope for splicing, etc., or for working marline around a seizing.

Parcelled.—Wrapped with canvas, rags, leather, etc., to resist chafing.

Seize.—To lash a rope permanently with a smaller cord.

Serve.—To lash with cord, etc., wound tightly and continuously around the object.

Splice.—To connect ropes' ends together by unlaying the strands of each and then plaiting both up together so as to make one continuous whole.



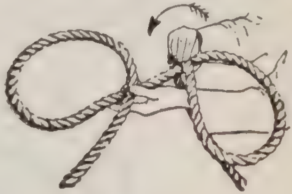
FIGS. 2,132 to 2,136.—Sheepshank. Form a bight and lay it against the rope leaving below it a second bight or loop as long as is needful for reducing the rope to the required length as in fig. 2,132. Holding the first bight with the right hand, with the left hand throw a half hitch around it as indicated by the arrow in fig. 2,132 and as shown in fig. 2,133. With the left hand grasp the sides of the second bight and with the right hand throw a half hitch of the rope over this bight by turning the right wrist, as indicated by the arrow in fig. 2,134, and as shown in the finished sheepshank in fig. 2,135. If it be desired to shorten the rope permanently, the ends may be passed through the first and second bights, as shown in fig. 2,136. The sheephsank *is used for* shortening a rope, is made quickly and without access to the ends. It may be tied in a rope and the rope may then be cut at the end of one of the two bights or along the central part in fig. 2,135, after which a strain may safely be put on the rope just as if it were not cut. It is said that this fact is utilized by steeple climbers who, before lowering themselves by ropes from towers where they have been at work, make a sheepshank near the upper end of the rope, cut it as described above, lower themselves to the ground, and then loosen the sheepshank by shaking it, when the cut rope falls to the ground leaving only a short end up on the tower.

Strand.—Two or more larger yarns twisted together.

Taut.—Stretched or drawn tight, strained.

Yarn.—Fibres twisted together.

Theory of Knots.—According to Kent, the principle of a knot is that "no two parts which would move in the same direction if the rope were to slip, should lay along side of and touching each other." Another principle that should be added to



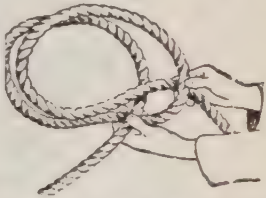


Fig. 2,137.—Anchor bend. This hitch, also called fisherman's bend, is used for fastening a rope securely to a metal ring, such as that on an anchor, with a double rope in contact with the metal to prevent excessive wear. ***To make,*** take a round turn around the ring and then two half hitches around the rope, passing the end for the first half hitch through the loop of the round turn as shown. In this form the hitch is very secure, but it may be made more so by whipping the end to the main rope.

Fig. 2,138.—Combined timber, and half hitch. This secure fastening is useful in handling long articles that must be kept in line with the pull of the rope. Note that the half hitch is around the object this time, and not around the rope.

Figs. 2,139 and 2,140.—Clove hitch. ***This consists of*** two half hitches arranged for fastening a rope around an object. It may be made in the middle of a long rope without access to the ends, and will stand a pull from either direction without slipping when once properly set. It is easily undone and is a very useful hitch. 1. ***Beginner's method:*** By twisting the rope to the right with the right hand, form two loops in a figure eight with the ends of the rope side by side at the center and extending in opposite directions, as shown in fig. 2,139. By still further twisting the right hand in the same direction, as indicated by the arrow in fig. 2,139, the hitch is thrown into the completed form as shown in fig. 2,140. Put the loops over the object and pull taut. 2. ***Hand and toe method:*** This is used by sailors for heavy rope. Draw the rope along the floor from left to right across the toe of the right foot, and then swing it around back again from right to left, forming a loop. With the foot turn the whole loop upside down and over to the left. Then form a second loop by swinging the rope around in the same direction as before. The loops will then be arranged as in fig. 2,139, except that the eft hand rope will in this case come down from above instead of up from below as in the picture, and the right hand one will go from below upward. Pick up the loops, folding them together as in fig. 2,140.

the above is that a knot or a hitch must be so devised that the *tight part of the rope must bear on the free end in such a manner as to pinch and hold it, in a knot, against another tight part of the rope, or in a hitch, against the object to which the rope is attached.*

The principle is illustrated in the Stevedore's knot, figs. 2,111 and 2,112, and in the half hitch, fig. 2,113.

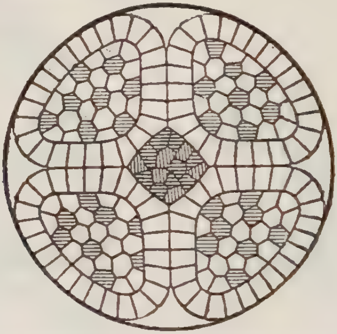


FIG. 2,141.—American transmission rope showing lubricated and cover yarns

FIGS. 2,142 to 2,144.—Elements of a knot. Fig. 2,142, bight; fig. 2,143, loop or turn; fig. 2,144, round turn. In fig. 2,142 the bight is formed by simply bending the rope, keeping the sides parallel; in fig. 2,143, the loop or turn is made by crossing the sides of a bight; in fig. 2,144 the round turn is produced by further bending one side of a loop.

The elements of a knot or bends that a rope undergoes in the formation of a knot or of a hitch are of three kinds:

1. Bight.
2. Loop or turn.
3. Round turn.

These are shown in figs. 2,142 to 2,144.

Knots and hitches are made by combining these elements in different ways conforming to the principles of a knot given above.

For example, the half hitch (fig. 2,113) is a loop around a rope, with the free end locked under the rope; the clove hitch (fig. 2,119) consists of two loops over a post; the sheepshank (fig. 2,136) is a round turn and two loops; the bowline knot (fig. 2,097) is a loop with a bight through it and around the main rope; the weaver's knot is the same as the bowline knot, except that the ends take a somewhat different direction.

Effect of Knots.—A rope is weakened by knots because in order to form a knot, the rope must be bent which brings most

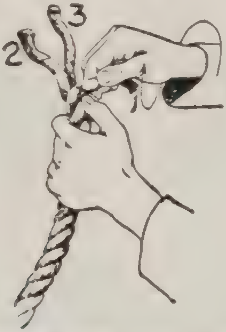
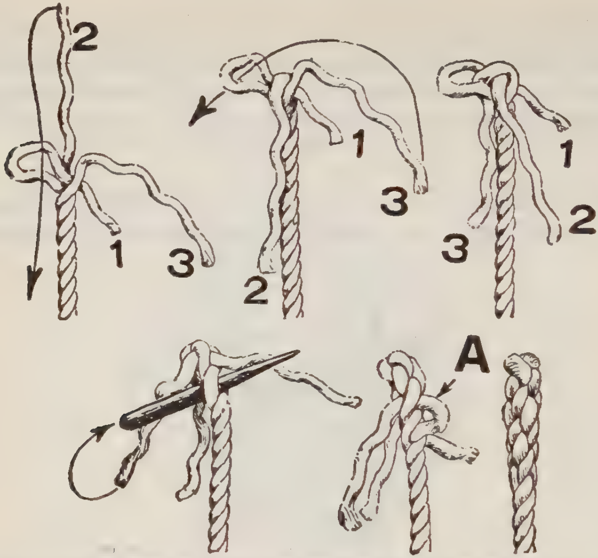


FIG. 2,145.—Relaying. *In performing* this operation, the rope is held in the left hand, and strand No. 1 is twisted up tightly by turning the right hand as indicated by the arrow around the wrist. This strand is then pulled down snugly into its place in the rope and is held there by pressing the left thumb on the point X. The rope should not be turned in the left hand. The next step is to grasp strand No. 2, twist it up tightly, lay it in snugly above No. 1, holding it with the left thumb by pressing on a point on No. 2 just above the point X, and on the same side of the rope. The left thumb should not work around the rope, but should move straight up the same side. Strand No. 3, is treated as was No. 2 and then No. 1 is in place to be laid in above No. 3. This process is repeated until the end of the rope is reached and it should result in the return of the rope to its original condition provided the strands themselves be not too badly untwisted; in the latter event it is cheaper to cut off the rope than to try to relay it.

of the strain on the outside fibers; the overloading breaks the outside fibers, increasing the strain on the fibers below which later break and soon the entire rope breaks.

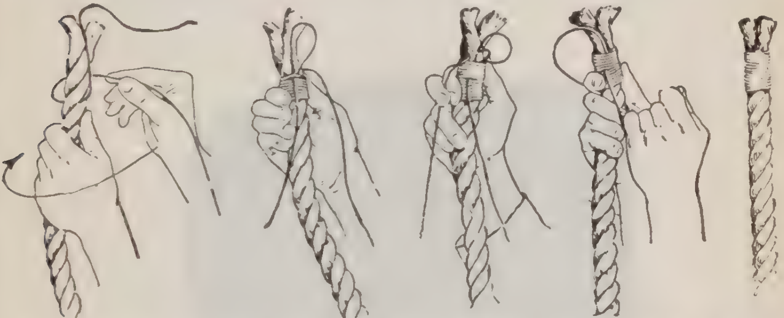
From experiment by Prof. E. F. Miller the approximate efficiency of knots, hitches and splices varies as follows: straight



FIGS. 2,146 to 2,151.—Crowning. Unlay the rope from five to ten inches more, according to size. Hold the rope in the left hand with the loose strands up. Select as No. 1, the strand on the left. Lay the strand across the end of the rope and between the other two strands, leaving an open bight projecting to the left as in fig. 2,146. Bring the rear strand, No. 2, forward and down over No. 1, as indicated by the arrow, fig. 2,146, into the position shown in fig. 2,147. Strand No. 3 now goes over No. 2 and down through the bight left in No. 1, as indicated by arrow in fig. 2,147, into the position shown in fig. 2,148. Pull the crown down tightly. Now proceed to splice back the loose ends. Each one is to pass over the nearest strand of the main rope and under the one beyond in a direction diagonally to the right, which is approximately at right angles to the strands of the rope. For the work procure a ***marline spike*** or smooth, round hardwood stick, pointed at one end and rounded at the other. With this instrument raise a strand of the rope close to where the loose ends project, and in the hole thus made insert the end of the proper loose strand as indicated by the arrow in fig. 2,149. Draw it down firmly. This process is called tucking the strand. Raise the strand of the rope next beyond and tuck the next loose strand under it. Then tuck the third strand. Draw all down securely. The loose strands should be given two or three more tucks, each strand receiving only one tuck at a time. As the strands are drawn down into place they tend to twist and kink. This tight twisting causes the tucked strand to stand out from the main rope and makes the splicing bulky. In order to prevent this, just before the strand is pulled into place untwist it at point A, fig. 2,150, and hold down about an inch of the loosened strand with the left thumb. Now draw down all of the strand not held by the thumb. A kink will form which must be drawn through, leaving the loosened strand that was held by the thumb to spread out in a thin band against the main rope. By cutting out some of the material of each strand after each tuck, the splice may be neatly tapered into the main rope, as shown in fig. 2,151. Do not cut the ends of the strands too close to the rope, as they are likely to draw back with use and become untucked. With a smooth round stick pound the splice down solid, and roll it on the floor under the foot.

rope 100%; eye splice over an iron eye, 90%; short splice 80%; timber hitch anchor bend, 65%; clove hitch running bowline, 60%; over hand knot, 45%.

Treatment of Rope Ends.—The process of building up a rope from strands is called ***laying a rope***, and so twisting to-



FIGS. 2,152 to 2,156.—Whipping the end of a rope. ***To whip:*** Unfray one strand of the rope back to the point where the whipping is to begin. Under this strand lay the twine, leaving the end eight or ten inches long as shown in fig. 2,152 and the relay then strand into the rope keeping it twisted up tightly and pulled hard down into its place as directed for relaying. If an especially secure whipping is to be made, the twine may be tied about the strand under which it is tucked; usually however, this is not necessary. Whip the long end of the twine around both the rope and the short end of the twine, being careful to pull it up tightly and to leave no vacant spaces between turns. When about half the desired distance is covered, bend back the short end of the twine so as to form a bight extending out beyond the end of the rope and begin whipping over both sides of the bight as shown in fig. 2,153. Continue whipping as far as desired and then pass the long end of the twine as closely as possible. Figs. 2,154 and 2,155 show steps in the process and fig. 2,156 the completed result.

gether strands that have become untwisted is called ***relaying,*** the latter process being shown in fig. 2,145.

Whipping consists in binding the end of a rope with twine to prevent it untwisting as in figs. 2,152 to 2,156.

Ropes that are to be passed through pulley blocks, or like halter ropes, through small holes, should be finished in this way. A method of doing this so that both ends of the twine are

fastened by tucking under the whipping is shown in figs. 2,152 to 2,156.

Crowning.—This is a neat, secure and permament method of fastening the strands of a rope when a slight enlargement of the end is not an objection. Figs. 2,146 to 2,151 show how this is done.

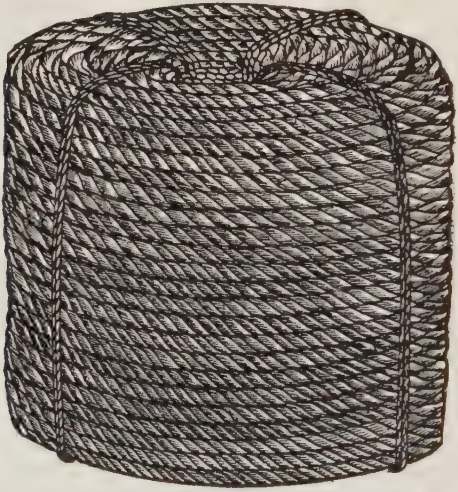


FIG. 2,157.—Coil of Manilla rope. ***Properties:*** Diameter 3/16 to 3 3/8; length 3,000 to 1,200 ft.; weight 33 to 3,580 lbs.; strength 500 to 75,000 lbs.

Emergency Trip Sling.—It is sometimes desirable to use a sling that can be tripped and the load dropped, without slacking up on the hoisting rope as is done with a regular trip sling for hay. If such a sling be not at hand, a substitute may be made as follows:

Procure a piece of rope of sufficient length, splice or tie the ends together to make it endless, draw the loop out long, and lay on it the material to be raised. Pull the sling up around the load and lay one end of the sling on the double ropes of the other end, as is done in fig. 2,098. Throw a half hitch over the first end, as shown in fig. 2,099, getting the hitch as near the load as possible and at the same time leaving the end A, only long enough to hold. In this case the two ropes extending upward in fig. 2,099 would be joined, forming a bight. Into this bight fasten the hoisting rope and begin hoisting gradually, watching the hitch to see that it becomes properly set.

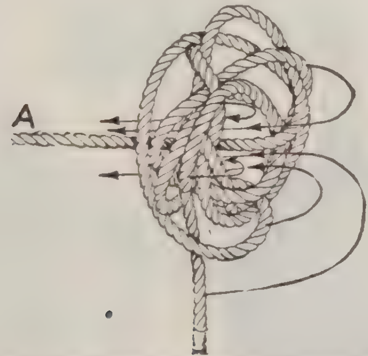
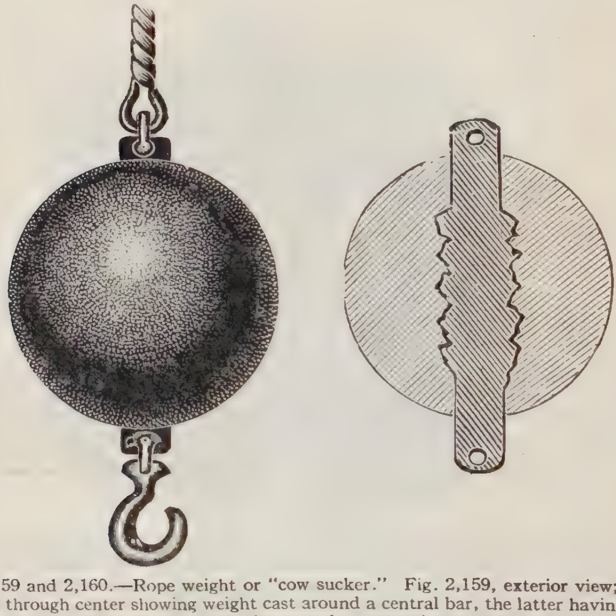


FIG. 2,158.—How to undo a snarl: *Begin* by loosening it, drawing out one end as far as possible as at A, and then opening the center of the snarl so as to form a hole of considerable size around the rope A. The whole bundle of tangled rope is then seized and forced through the hole thus made, putting the outside part of the bundle through first as shown by the arrows, a process much like kneading bread. This will add a little straight rope to the end A, and if patiently continued, the process will surely unravel the worst possible tangle.

If a trip rope be fastened at the point held by the left hand in fig. 2,099, the hitch may be tripped by a sharp pull toward the right. It must be remembered that this is only an emergency hitch and, while quite secure when properly set, it will give way if not so set. Therefore it is necessary to keep from beneath the load.

Care of Ropes.—Hemp is easily rotted by the influence of damp; hence, if the ropes have been used in the rain or allowed to get into water, they must be hung up to dry. A beam within

a shed, some eight or ten feet above ground, is most convenient for this purpose, the rope being passed over it from one side to another, and hanging down in loose festoons on each side *well clear of the ground*. This facilitates the circulation of the air around each part of the rope. *On no account* should a rope be coiled up when wet, as the internal covered parts absorb all the moisture and quickly rot.



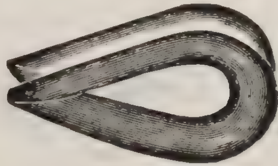
FIGS. 2,159 and 2,160.—Rope weight or "cow sucker." Fig. 2,159, exterior view; fig. 2,160 section through center showing weight cast around a central bar, the latter having a hole at each end to receive the load hook and an eye for connecting to the rope.

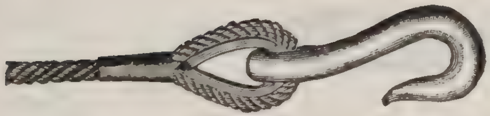
Constant inspection is necessary, as unlooked for damage may be occasioned by the parting of a rope. A good method of inspecting the inside fibres is by partially untwisting the strands by moving each hand in opposite directions as they hold the rope; this gives an opportunity of examining the under side of the strands.

The strain and chafing cause rupture of the fibres, which must be seen to. Much of this trouble may be obviated in the case of standing ropes by using "parcelling," or chafing gear, of rags, marline or leather bound around the rope to protect it.

Always suspect a rope that has lain in a warm place, such as a boiler house. It may have "perished" and is not trustworthy.

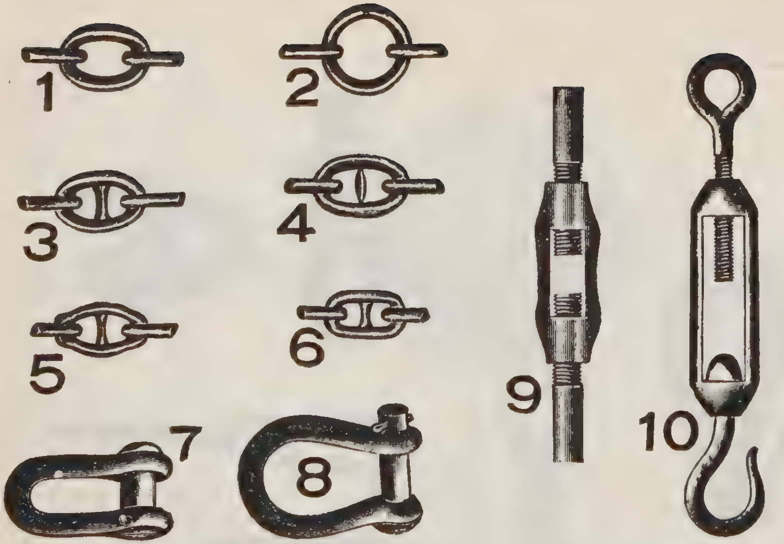
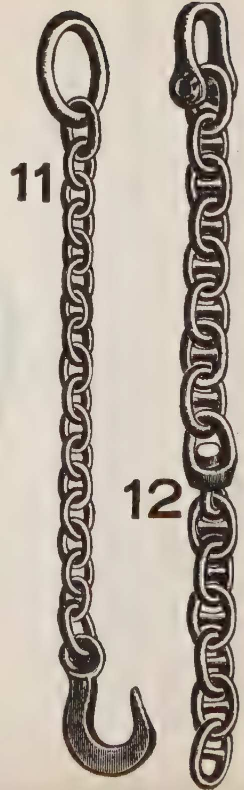
Ropes that have to be exposed to wet are rendered more durable by





FIGS. 2,161 and 2,162.—Wire rope fastening *1*. Thimble, and hook and thimble.

FIGS. 2,163 to 2,166.—Wire rope fastenings *2*. Figs. 2,163 and 2,164, closed and open sockets; fig 2,165, atlas clip; fig. 2,166, Crosby clip.

FIGS. 2,167 to 2,178.—Chains and chain fittings. **1**, oval link; **2**, circular link; **3**, oval stud link with broad headed stud; **4**, oval stud link with pointed stud; **5**, obtuse angle stud link; **6**, parallel side link; **7**, chain or cable shackle; **8**, common anchor shackle; **9**, ordinary turn buckle; **10**, hook and eye turnbuckle; **11**, close link chain sling; **12**, length of stud chain with swivel in the middle permitting rotary motion without fouling the chain.

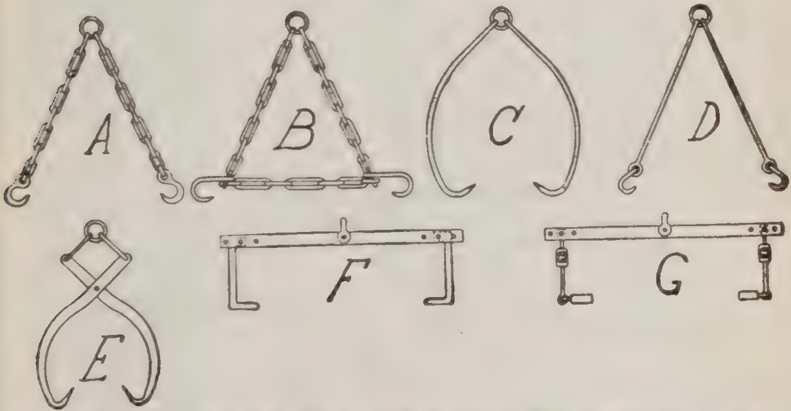
coating the yarn with Archangel tar in the process of making. This, however, reduces the strength of the rope by one-fourth.

It may be advisable to state here that rope makers generally specify all

their ropes in terms of the *circumference*, and the various formulae for weight and strength are all calculated from that dimension.

Rope Weights.—Manila, or wire rope for hoisting is usually provided with a rope weight or *cow sucker*, as shown in figs. 2,159 and 2,160. The object of this weight is to cause the rope to unwind or pay out when released.

Chains.—These are made of round bar iron or steel forged into links, by bending to shape and welding.



Figs. 2,179 to 2,185.—Various slings and tongs or grapples, showing types most frequently used. The number of chains, number and shape of hooks, etc., may be varied to meet conditions.

The stud is a distance piece, usually of cast steel, which serves to strengthen the link; it is used on the larger sizes alone and permits a longer link. Most chains for heavy stresses are made this way.

Fig. 2,177 (**11**) shows a close link chain sling, having a large open circular link in which the hook engages. A length of stud chain is illustrated in

fig. 2,178, and is noteworthy on account of the swivel in the middle of its length, permitting rotary motion without fouling the chain.

Turnbuckles are generally used to strain both chains and ropes taut, fig. 2,176 being what is termed a hook and eye turnbuckle adapted for tightening the shrouds or guys of a flagstaff post or derrick. Fig. 2,175 is an ordinary type of turnbuckle, sometimes known as a stretching screw, provided with right and left hand threads to tighten stays, etc.

Working Loads of Chain Blocks

Capacity in Tons	Pull in Pounds Required on Hand Chain to Lift Full Load			Feet of Hand Chain to be Pulled by Operator to Lift Load One Foot High		
	Triplex	Duplex	Differential	Triplex	Duplex	Differential
¼	.....	......	72	....	......	18
½	62	68	122	21	40	24
1	82	87	216	31	59	30
1½	110	94	246	35	80	36
2	120	115	308	42	93	42
3	114	132	557	69	126	38
4	124	142	......	84	155	......
5	110	145	......	126	195	......
6	130	145	......	126	252	......
8	135	160	......	168	310	......
10	140	160	......	210	390	......

Lifting Capacities of Air Hoists

Inside Diameter of Cylinder, Inches	Lifting Capacities at Various Air Pressures (Actual), in Pounds			Cubic Feet of Free Air used per Ft. of Lift at 60 Pounds
	At 60 lbs.	At 80 lbs.	At 100 lbs.	
3	380	510	630	0.3
4	680	900	1,130	0.45
5	1,060	1,410	1,770	0.68
6	1,530	2,040	2,540	0.99
7	2,080	2,770	3,460	1.36
8	2,710	3,620	4,520	1.75
10	4,250	5,660	7,080	2.77
12	6,160	8,220	10,280	3.99
14	8,310	11,080	13,850	5.42
16	10,860	14,480	18,100	6.91
20	16,960	22,620	28,280	11.10
24	24,430	32,570	40,720	15.80

A chain or cable shackle as seen in fig. 2,174, is used for connecting lengths, usually 15 fathoms, of a cable; the bolt has

countersunk head and is locked by a wooden or brass taper pin, as iron would rust in. Fig. 2,174 (*8*) represents the common anchor shackle, in which the pin is attached by a cotter or fore lock; this type is occasionally termed *clevis*.

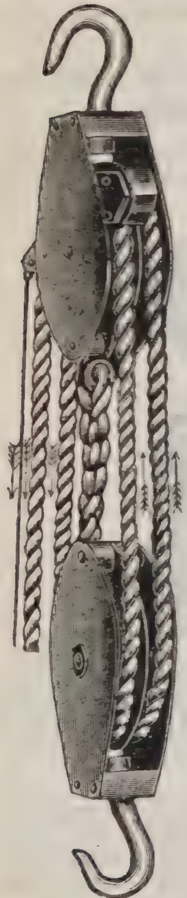


FIG. 2,186. — Block and tackle. The arrows show the direction of travel of the rope.

Chains, both stud and close link, should be obtained from reliable sources. In view of possible deterioration and the severe strains to which they are subjected, crane chain slings, etc., should not be worked above a safe load.

Crane chains require to be taken off twice a year and annealed; that is, placed in a muffle or reverberatory furnace, brought slowly to a red heat, and cooled off gradually, covered the while with ashes or sand to exclude the air. This process is rendered necessary on account of the crystallization or alteration of fibre set up in the metal by the constant jar and reversal of strain. Broken crane chains often exhibit a granular fracture like cast iron.

2. The Gearing

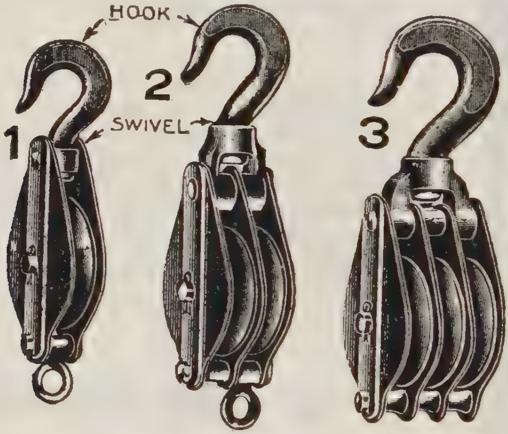
Combination of Pulleys.—For lifting heavy weights recourse is had to the mechanical power known as *the pulley*, consisting in its simplest form of a grooved wheel rotating on an axis. The mere passing of a rope over one fixed pulley for hoisting a weight does not give any increase of power, the force necessary to sustain the weight being equal to the latter, plus friction of the rope, etc.

The combination of ropes and pulleys to gain a mechanical advantage in lifting a load is known as a *block and tackle.*

The block consists of shell, pulley, and hook or eye. Usually two blocks are used.

The rope or chain connecting the blocks and by which they are worked and the load hoisted is called the *tackle.*

The block and tackle gives a "mechanical advantage" in the application of the power, for instance, it is easier to haul downward on a pull of say 100

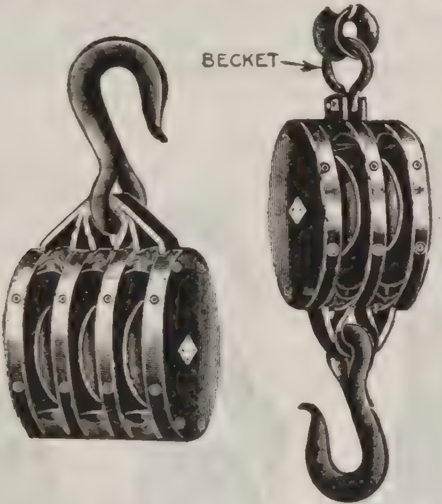


FIGS. 2,187 to 2,189.—Iron sheave blocks. **1**, single sheave; **2**, double sheave; **3**, three sheave. These united to form a tackle similar to fig. 2,186, are used for handling weights by manual power, the lower block generally having one sheave less than the upper. The standing end of the rope is seized to the *becket** of the lower block, *rove* first through the upper, then the lower, and so on until the fall finally depends from the upper.

lbs. than it is to lift 100 lbs. directly from the ground. This mechanical advantage should not be confused with the multiplication of effort. Thus, according to the "degree of gearing" the 100 lb. weight may be lifted by the application of less force as 50, 25, 10, 5 lbs. pull, etc. For instance, when one end of the rope is fixed, passes *under* a single pulley to which the load is attached and the free end is lifted, the travel of the rope or cord is double that of the weight, and the power necessary to sustain the latter is half the weight plus friction. It may be stated in the reversed proposition, that

with a *movable pulley* the weight capable of being lifted is *twice the force applied* minus the friction of the apparatus.

Combinations of pulleys are arranged with several sheaves in one case, to form a block to secure this multiplication of power. The upper or fixed block gives the mechanical advantage of application, and the lower or movable block, by multiplying the travel of the rope as compared with



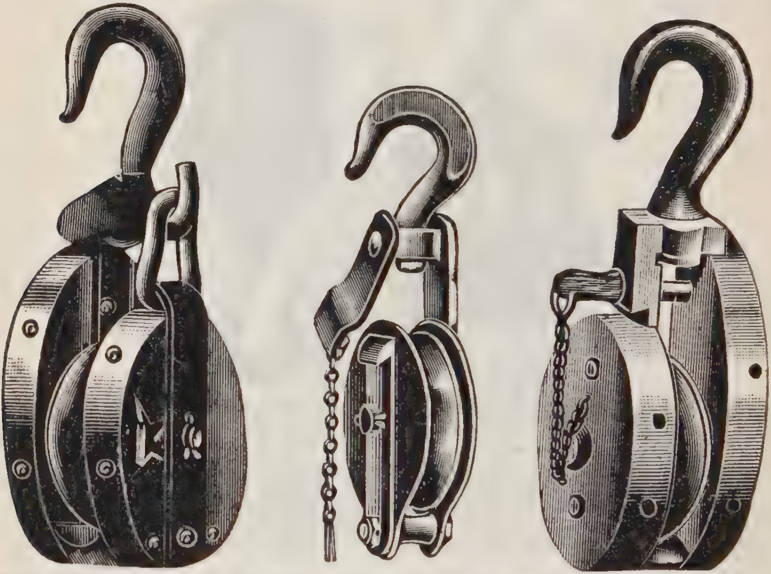
FIGS. 2,190 and 2,191.—Wooden blocks. Fig. 2,190, three sheave; fig. 2,191, two sheave Wooden blocks are used out of doors in preference to iron ones, in connection with derricks gin poles or rigging as they will stand the weather and rough usage better. The sheaves are of brass or of lignum vitae bushed with bronze, working on a steel pin. The two blocks here shown are commonly united by rope, the assembly being called "*block and tackle*" or briefly *tackle*. Some denominate blocks by the number of times the rope or *block fall* passes the lower pulleys, hence the combination here shown would be called a four run block. The mechanical gain is five fold. Since *there are five ropes supporting the lower or movable block*

that of the weight, increases the power in proportionate ratio. Each movable pulley halving the power necessary, with two sheaves the force necessary is one-half of one-half or one-quarter. Briefly, the weight capable of being lifted is equal to the *force multiplied by the number of ropes supporting the lower or movable block*.

*NOTE.—*Beeket;* by definition: a loop at the lower end of a block to which the standing part of the fall is made fast.

Examination of the block and tackle shown in fig. 2,186 will make this clear, the arrow heads showing the direction of travel of the rope, or *fall*, as it is termed. The thin cord shown manipulates a patent brake, seen in the upper block, which locks the rope should it be desired to suspend the object lifted.

It will be evident, upon consideration, that no two sheaves travel at the same velocity, on account of the varying speed of the different parts of the rope. *It is therefore requisite that the sheaves be independent of each other*, revolving loosely upon a spindle fixed in the shell or frame of the block.



FIGS. 2,192 to 2,194.—Snatch blocks. Pulley blocks have frequently to be used as fair leads or guide pulleys, for a block fall to a winch or capstan, when the pull is not in a straight line; and in that connection it is very inconvenient to have to reeve or unreeve a long rope through the sheave. To save this trouble, part of one cheek of the block is made to work on a hinge or joint, forming a *snatch block*, three types of which are here shown. Fig. 2,192 is locked by a link and bent pin, which latter is turned around to release the latch. A common iron snatch block is shown in fig. 2,193, the cheek swinging clear to get the rope in or out, locking on a wedge and fastened by a split pin. The usual type on shipboard has the movable part working on a hinge, and locking by means of a forelock or cotter thrust through a pin protruding from the fixed part through a hole in the latched portion. Fig. 2,194 shows what is known as the burr pattern, the hinge being locked by means of a wooden pin.

A basal factor of all mechanical powers is, that *whatever is lost in time is gained in load lifted*, or the reverse. It has been seen that with the weight traveling half as fast as the rope, double the weight could be lifted with the same force, or a force of only half the weight was necessary.

In *practice* the friction losses must be considered in estimating the power required to lift loads by blocks. The following table may be used in estimating the power required.

Working Loads of Rope Blocks

Number of Rope Lengths Shortened	Manila Rope		Wire Rope	
	Ratio of Load to Pull	Efficiency, Per Cent	Ratio of Load to Pull	Efficiency, Per Cent
2	1.91	96	....	....
3	2.64	88	2.73	91
4	3.30	83	3.47	87
5	3.84	77	4.11	82
6	4.33	72	4.70	78
7	4.72	67	5.20	74
8	5.08	64	5.68	71
9	5.37	60	6.08	68
10	....	....	6.46	65
12	....	....	7.08	59

NOTE.—*Pneumatic Hoists.* 1, *Air balanced type.* This form of pneumatic hoist is so arranged that there is full air pressure on the stuffing box side of the piston at all times. The load is hoisted by exhausting air from the space above the piston, and is lowered by admitting air above the piston; the unbalanced area due to the space occupied by the piston rod aids in forcing the piston downward. The advantage of this arrangement is accuracy of control. These hoists are adapted for use in foundries for setting cores, for closing molds, drawing patterns, and for many other purposes requiring a comparatively delicate control of the hoisting movement. 2, *Double acting type.* This type differs from the balanced type in that air may be admitted and exhausted from either side of the piston, so that the latter may be moved in either direction with equal power. Thus, with a balanced hoist, there is a constant pressure on one side of the piston and a variable pressure on the other, whereas with a double acting type, the pressure on either side of the piston may be varied in accordance with the amount of the load and the direction in which the force must be applied. For this reason, hoists of the double-acting type are used whenever either a pushing or pulling effect may be required. 3, *Horizontal hoist.* In certain locations, the standard vertical air hoists are not applicable owing to the limited amount of head-room available, and special horizontal hoists are sometimes used, under these conditions. One method of arranging such a hoist is to equip the hoist with a sheave at the end of the piston rod, instead of a hook and attach the lifting hook to a wire rope which passes around the piston rod sheave and over an idler sheave, so that the hook will be raised or lowered as the horizontal piston moves out or in.

NOTE.—Lifting capacities and other data on air hoists are given in the table on page 1,052

Example.—What force (pull) must be applied on a block and tackle having four rope lengths shortened to lift 500 lbs.

For four rope lengths, according to the table, the ratio of load to pull is 3.3. Accordingly, a force applied = 500 ÷ 3.3 = 151.5 lbs.

Example.—If a pull of 100 lbs. be applied on a block and tackle having a ratio of load to pull of 4.33, what load can be lifted?

$$100 \times 4.33 = 433 \text{ lbs.}$$

The table of Yale and Towne chain hoists which follows gives working loads for various chain blocks and feet of chain to be pulled by operator to lift load one foot.

DUPLEX DOUBLE CHAIN WORM WHEEL BLOCKS

Capacity in Tons	Regular Hoist in Feet*	Minimum Distance between Hooks in Inches	Chain Pull†	
			Lbs.	Feet
½	8	13	68	40
1	8	16	87	59
1½	8	19	94	80
2	9	21	115	93
3	10	25	132	126
4	10	29	142	155

†NOTE.—Figures denote the pull in pounds required to lift the full load, and the number of feet of hand chain which must be handled to lift the load one foot.

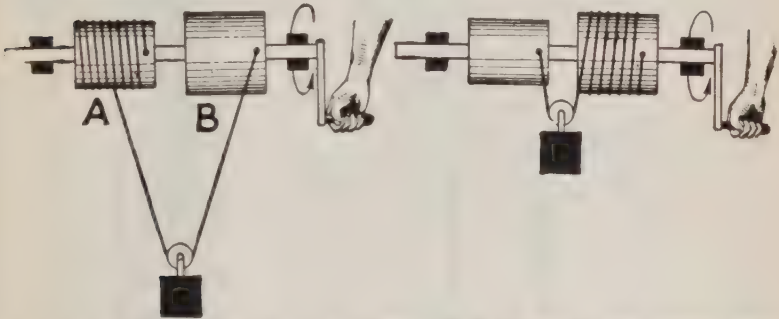
*NOTE.—Figures denote height in feet which blocks with regular lengths of chain will hoist from level on which operator stands.

SCREW GEARED TRIPLEX BLOCKS

Capacity in Tons	*Regular Hoist in Feet	Reach in Feet and Inches	Minimum Distance between Hooks, in Ins.	Net Weight in lbs.	Chain Pull in lbs. to lift Full Load	Feet of Chain Handled to lift load one Foot
½	8	9′-3″	15	53	62	21
1	8	9′-5″	17	80	82	31
1½	8	9′-7½″	19½	124	110	35
2	9	11′-0″	24	188	120	42
3	10	12′-8″	32	200	114	69
4	10	13′-1″	37	290	124	84
5	12	15′-9″	45	380	110	126
6	12	15′-10″	46	390	130	126
8	12	16′-3″	51	470	135	168
10	12	16′-9″	57	570	140	210
12	12	16′-9″	57	800	130†	126†
16	12	17′-1″	61	1000	135†	168†
20	12	18′-5″	77	1375	140†	210†

*NOTE.—Figures denote height in feet which blocks, with regular lengths of chain, will hoist above level on which operator stands.

Differential Blocks.—This heavy duty type of hoist or chain block was invented by Thomas A. Weston in 1854 and is comparatively inexpensive and simple in construction. It is based upon the principle of the Chinese windlass shown in fig. 2,195 and 2,196. An inspection of the figures will show that the differential block depends for its utility upon a very slow speed of the weight in comparison with the speed of the haul. This is secured by making the two upper pulleys of nearly the same



FIGS. 2,195 and 2,196.—Chinese windlass illustrating the principle of the differential hoist. *It consists of* two drums, A and B (one a little larger than the other) connected to a shaft and having the ends of a lifting cable attached to the drum as shown, so that in turning the crank the cable will simultaneously unwind on one drum and wind on the other. Fig. 2,195 shows the beginning of the lifting operation. As the crank is turned clockwise the cable winds on B, and unwinds on A, and since B, is larger in diameter, the length of cable between the two drums and load is gradually taken up, thus lifting the load. Evidently by making the difference in diameter of the two drums very small an extremely large leverage is obtained thus enabling very heavy weights to be lifted with little effort. The load will remain suspended at any point, *because the difference in the diameter of the two drums is too small to overbalance the friction of the parts*. Fig. 2,196 shows the end of the lifting operation.

size, the endless chain being *paid out* by one while it is *hove in* by the other. In other words, the smaller sheave tends to lower the weight while the larger one raises it, the total lift equalling the difference of circumference of the two sheaves. Assuming in this case that there are 25 sprocket teeth in the

larger sheave and 23 in the lesser, the velocity of haul as compared with that of the lift will be $\frac{2 \times 25}{25 - 23}$ or 25 to 1, consequently a pull of 80 lbs. will lift 1 ton or 2,000 lbs. This style of block is fitted with an endless chain, which obviates a serious objection to the principle of the differential windlass, namely,

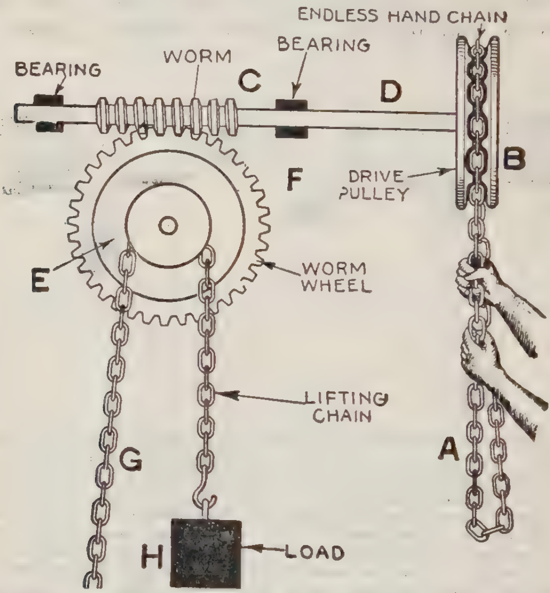


FIG. 2,197.—Elementary worm gear hoist. The hand chain A, is used for rotating the drive pulley B, which is connected to the worm by a shaft. The worm meshes with the worm wheel E, whose shaft is attached to the pulley F, over which passes the lifting chain G. The pulley F, has pockets for receiving the chain links so that the chain cannot slip in lifting the load H.

the great length of rope required if the displacement of the object moved is to be very large.

As the differential tackle is liable to mishaps in use, such as jamming of the chains, or slipping the load on jerking, and has the serious defect of

having only a certain length of chain, which precludes long lifts, other contrivances, such as worm and spur geared hoists have been designed to attain the same end.

Worm Hoist.—In this type of hoist (sometimes called screw hoist) the power is transmitted from a hand chain to the load chain by worm gearing, the principle of transmission being shown in fig. 2,197.

In the worm hoist an endless chain, passing around a sprocket or *gipsy wheel*, rotates a worm, and, by multiplying gearing, haûls on the lifting chain. Not only is the gain of power, at the expense of time, obtained by the multiple gearing of this device, but the *worm prevents slipping*, and as there is no weight on the hand chain *a jam is not dangerous*.

The name "Duplex" is applied to worm hoists having a double chain attached to the hook as in fig. 2,198.

Spur Gear and Drum Hoist.—This type of hoist is known as a *winch*, which by definition, is *a windlass, particularly one used for hoisting, as on a truck or the mast of a derrick, having usually one or more hand cranks geared to a drum around which the rope or chain winds, but sometimes rigged for steam power.*

FIG. 2,198.—Worm gear hoist. ***In operation,*** an endless chain, passing around a sprocket or *gipsy wheel*, rotates a worm, and, by multiplying gearing, hauls on the lifting chain. In the illustration this will be seen to be double, for giving a steady lift, and it is raised or lowered by the small gipsy wheels seen to the right. Not only is the gain of power, at the expense of time, obtained by the multiple gearing of this device, but the *worm prevents slipping*, and as there is no weight on the hand chain *a jam is not dangerous*.

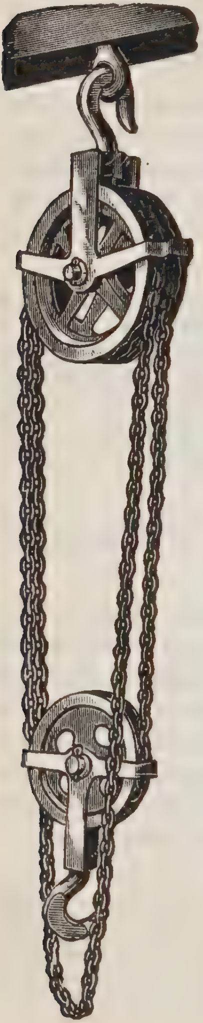


Fig. 2,201 shows a simple winch with single reduction gearing. It is fitted with a brake for lowering; a latch, seen near the further frame, holds the pinion or crank-shaft in gear. When desiring to lower, the load is held on the brake, the latch lifted, pinion shaft thrust to the right out of gear and locked, the load being lowered on the brake without the handles revolving.

When using a winch of this description for wire rope, the barrel or drum should be at least twenty times the diameter of the rope.

Figs. 2,202 and 2,203 show a combined single and double reduction winch having a greater capacity range.

Example.—In the double reduction winch shown in figs. 2,202 and 2,203 if gear L, have 60 teeth, gear A, 10, gear R, 24 and pinion F, 8, and the crank arm be twice the radius of the drum, what load can be lifted for a boring force of 100 lbs. applied to the crank handle?

$$\text{Ratio of L to A} = 60 \div 10 = 6$$

$$\text{Ratio of R to F} = 24 \div 8 = 3$$

$$\text{total ratio of double reduction} = 6 \times 3 = 18$$

$$\text{ratio crank arm to drum radius} = 2$$

$$\text{total gearing ratio between handle and rope } 2 \times 18 = 36$$

$$\text{load lifted for 100-lb. pull on crank} = 100 \times 36 = 3{,}600 \text{ lbs.}$$

FIG. 2,199.—Differential hoist. ***It depends*** for its utility upon giving a very slow travel of the weight in comparison with the speed of the haul. This style of block is fitted with an endless chain, which obviates a serious objection to the principle of the differential windlass; namely, the great length of rope required if the displacement of the object moved is to be very large. This type of hoist is adapted to many purposes although it is inefficient as compared with other designs in which the reduction is obtained through gearing and is also comparatively slow in operation. Ordinarily made in capacities ⅛ to 3 tons.

Spur Gear and Spool Windlass.—In this type of hoist as shown in figs. 2,204 and 2,205 which represents a home made rig, the hauling rope is wrapped around the spool three or four

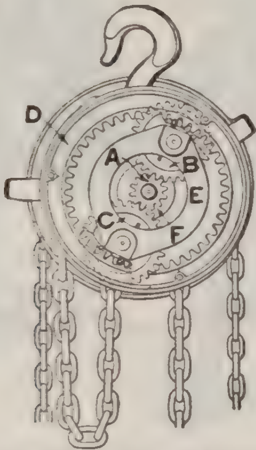


FIG. 2,200.—Planetary Spur geared "Triplex" block or hoist. The power is transmitted from the hand chain to the load chain. ***In operation***, when the hand wheel carrying the hand chain is rotated the pinion A, is also rotated and transmits its motion through two intermediate gears B and C, at two points always diametrically opposite each other. Pinions fixed to gears B and C, engage an internal gear D, which acts as a fulcrum and causes the pinion case E, to revolve. This pinion case is keyed to the sheave F, which carries the load chain of the hoist. The load is held at any given point and the hoist prevented lowering until the hand wheel is turned in the opposite direction, by a friction brake and ratchet mechanism. Motion from the hand wheel is transmitted through friction discs to a hub which drives the pinion A. The hand wheel is screwed onto a threaded extension of the hub, and interposed between these two parts is a ratchet disc. These discs, one of leather and the other of galvanized iron, are placed in contact with the sides of the ratchet disc, and the different pinions referred to are so arranged that, when the hand wheel is rotated in the direction for hoisting it is screwed onto the hub, hence the ratchet disc is gripped between the hand wheel and hub so that all the parts rotate together and motion is transmitted to the driving pinion A. Whenever the downward pull on the hand chain is discontinued, the load is prevented lowering by a pawl which engages the ratchet disc. When it is desired to lower the load, the hand wheel is pulled around in the opposite direction, which unscrews it somewhat, thus releasing the friction mechanism, which permits the hub to revolve, as the result of the force of the sustained load which is transmitted through the system of gearing and causes pinion A, to rotate. This rotating of the pinion and the hub on which the hand wheel is screwed causes the hub to tighten quickly, provided the rotary movement for lowering is discontinued. There is a continuous slippage between the friction surfaces as long as the hand wheel is rotated in the reverse direction. As soon as this rotation is stopped, the downward movement of the load is stopped.

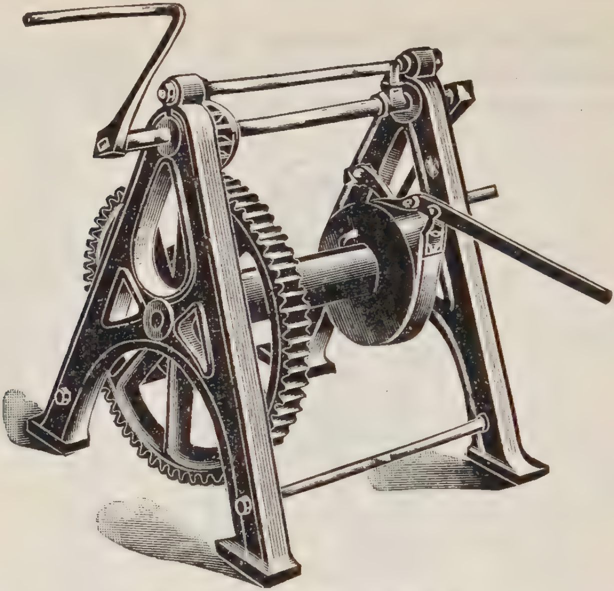
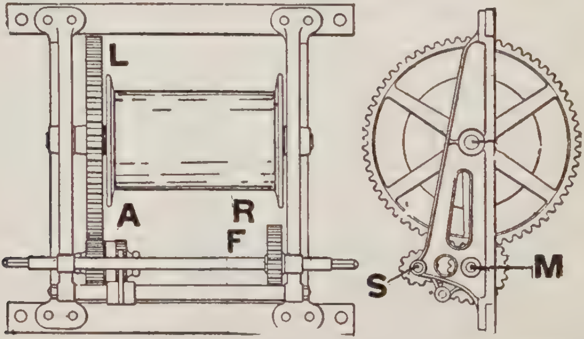


FIG. 2,201.—Crab or hand winch consisting of single reduction gearing with drum, brake, paul, and hand cranks.

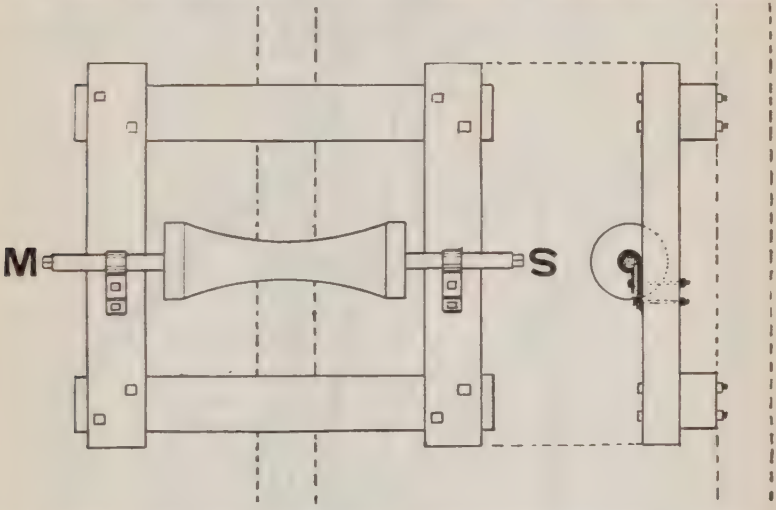


FIGS. 2,202 and 2,203.—Winch with combined single and double reduction gear. For light loads the handles are connected to shaft M, giving single reduction through gears LA, and for heavy loads they are connected to shaft S, giving double reduction through gears LARF. The winch is fitted with a brake for controling speed in lowering, and with a pawl for holding the load at any elevation.

times, one end fastened to the load and the other held taut while the crank is turned as in fig. 2,206.

3. The Supporting Structure

Gin Pole.—Erectors will find the *gin pole* of great use; this is a stout pole, of a length corresponding to the object desired



FIGS. 2,204 and 2,205.—Home made windlass. Cranks not shown are attached to the shaft at M and S. The spool tapers outward to the ends so that the three or four turns of rope taken around the spool will not run off as the winding progresses but slip back to the center. A windlass differs from a winch in operating principle in that the rope is paid out as fast as it is wound, depending on the friction due to the three or four turns to raise the load; the rope of a winch is fastened to the drum.

to be operated upon, which serves as a portable derrick to place upon their foundations objects which occupy a vertical position, such as iron chimneys, derrick masts, etc.

The gin pole and method of using it in placing a mast in position is shown in figs. 2,207 and 2,208.

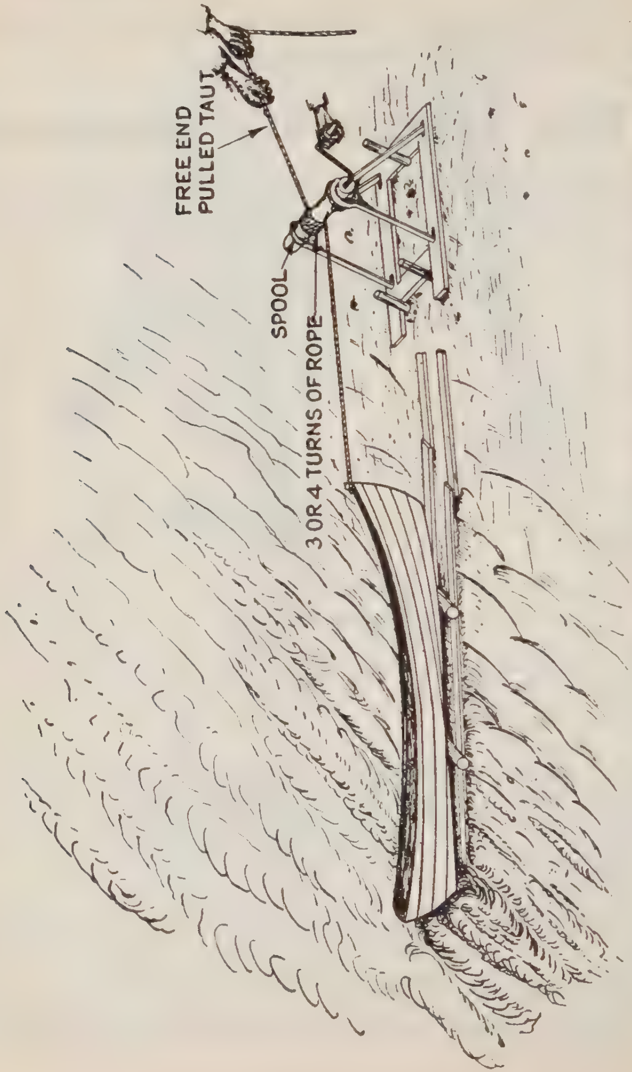
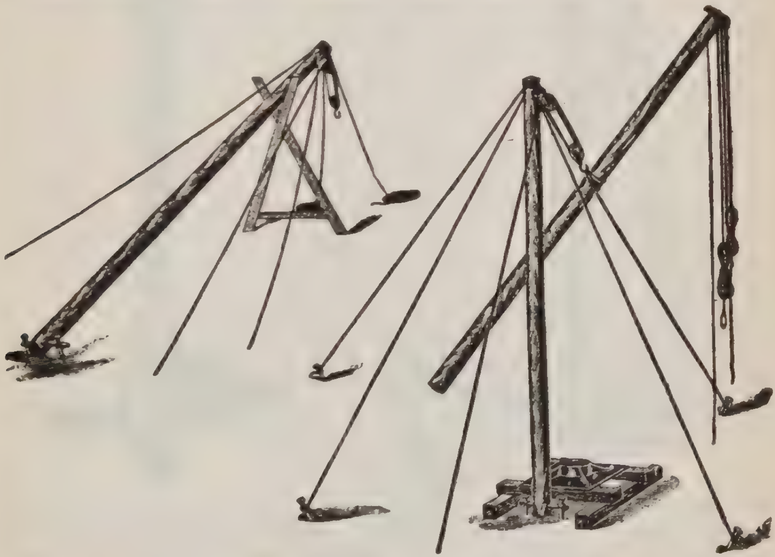


FIG. 2,206.—Home made windlass in operation hauling out a Sea Bright skiff. View showing turns of rope on spool, free end of rope pulled taut while crank is being turned.

Tripod or Shear Legs.—This is an old and well known hoisting device as shown in fig. 2,211. It consists of three sticks or legs fastened together at the top and from which point the tackle is suspended.

Different methods of fastening the legs together are used, that here shown being perhaps the most simple.

Stiff Leg Mast.—Another form of supporting structure consisting of a mast of suitable height and fixed by braces on a



FIGS. 2,207 and 2,208.—Gin pole and its use. ***In placing*** gin pole in position its outer end is temporarily supported on a trestle or horse to save distance in walking up. For fixing the stakes or "dead men," some little trouble must be taken, as a simple driven peg will not have sufficient holding power. A cross is made of stout wooden planks two or three feet long, the arms connected by a long eye-bolt or plain bar with enlarged head; the part of the bolt which passes through the cross arms being threaded and fastened above and below the planks by lock nuts. The ground is dug up, the cross arms buried to a depth of some three feet, with the eye bolt or swelled head protruding well above the surface. The earth is well rammed down into the ditch to increase holding power. A better contrivance is the screw anchor shown in fig. 2,210.

FIG. 2,209.—Stiff leg mast mounted on triangular base and secured in position by three "stiff legs" or braces extending from the vertices of the triangular base diagonally upward to the mast. Cross strips are nailed on permitting access to the top of the mast for fastening the pulley.

FIG. 2,210.—Screw anchor. ***It consists of*** a cast iron helix some twelve inches in diameter, with four inches pitch. The screw is "cast on" a wrought iron or steel shank of one and a half inch square section, which is suitably jagged to grip the cast metal. The shank is about six feet long, terminating in a three inch eye. This anchor is worked into the ground in similar fashion to a screw pile, and possesses remarkable holding power. Its superior hold is attributed to the fact that the surrounding earth is not disturbed in inserting it. Another advantage is the short space of time required to insert it as compared with digging a ditch for a "dead man" or other anchor.

triangular base is shown in fig. 2,209, the term "stiff leg" being applied to distinguish it from the mast secured by guy cables as in fig. 2,207.

Derricks.—By definition a derrick is *an apparatus for lifting and moving heavy weights.* It is similar to the crane, but differs from it in having the boom, which corresponds to the jib of the

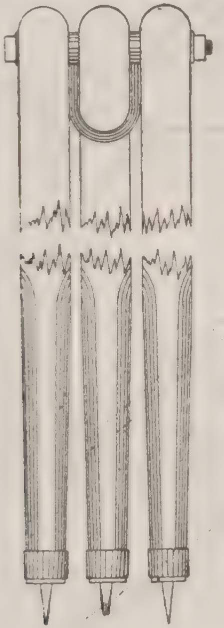
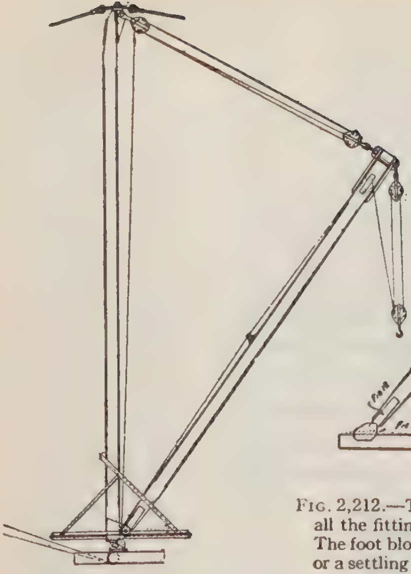


Fig. 2,211.—Tripod or shear legs. ***In construction,*** a hole for a good stout bolt is bored through all three legs; a U-shaped piece of iron called a shackle is placed in position as shown in the drawing and the bolt is run through to hold all together. The bolt should be left rather loose and after it is in place the threaded end should be riveted slightly to avoid the possibility of the nut coming off.

crane, pivoted at the lower end so that it may take different inclinations from the perpendicular.

The weight is suspended from the end of the boom by ropes or chains that pass through a block at the end of the boom and thence directly to the *crab*, or winding apparatus at



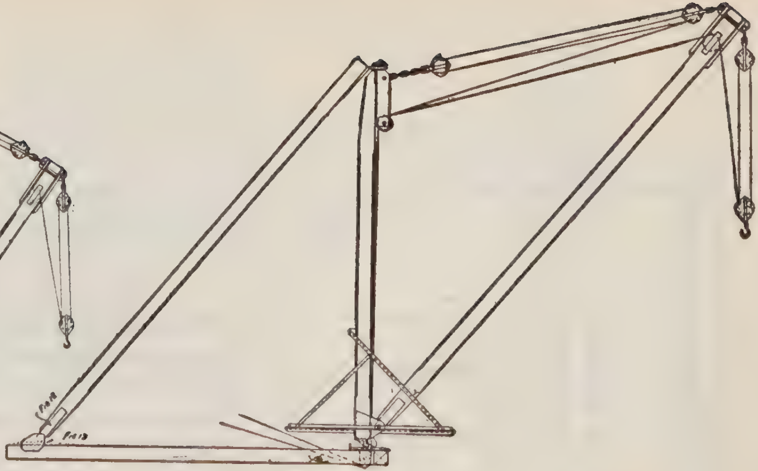


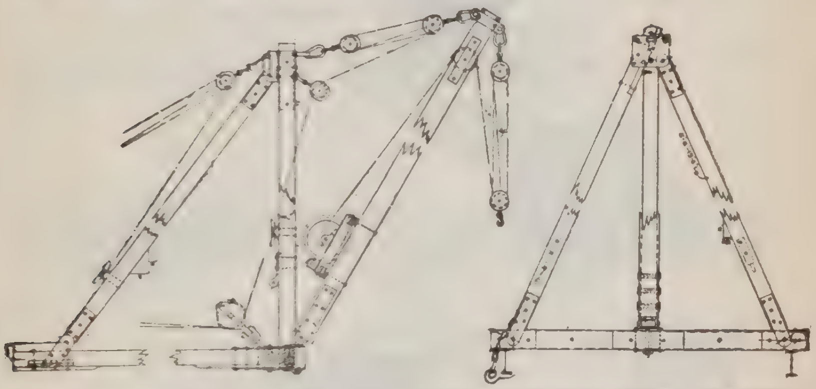
FIG. 2,212.—Terry standard guy derrick with bull wheel and swinging gear. ***In construction,*** all the fittings except the foot irons and sheaves are made of forgings or structural shapes. The foot block and mast slip are made with a ball and socket universal joint. Uneven setting or a settling of the derrick supports cannot make this joint pinch or retard the swinging of the boom. A back lock makes it impossible for the mast to be lifted clear of the step. The spider is made of buckeled plates. The regular set of iron for a guy derrick includes the mast head block, two sheaves in the foot block, one sheave in the mast step, and one sheave in the boom end.

FIG. 2,213.—Terry standard stiff leg derrick with bull head and swinging gear. This type derrick has, as its name implies, rigid timbers or "legs" in place of guys. ***In construction,*** the goose neck irons for the stiff legs are made very heavy at the bend and bent close in to the mast top. The back or stiff leg connections to the sills allow the stiff legs to be set at any angle. They require no framing. When it is desired to rig these derricks with the fall line down the boom, one of the mast top sheaves is put in the mast step. The length of the boom should be approximately 1½ times the length of the mast.

the foot of the post. Another rope connects the top of the boom with a block at the top of the post, and thence passes to the motor below.

The motions of the derrick are:

1. A direct lift.
2. A circular motion around the axis of the post.
3. A radial motion within the circle described by the point of the boom.



FIGS. 2,214 and 2,215.—Terry *"Jinniwinks"* or so called "A" frame derrick. This differs from the ordinary stiff leg derrick in that it has in place of a boom, two inclined timbers, fastened to a horizontal cross piece and a stiff leg fastened to a second horizontal member projecting backward at right angles with the first. It is thus made with the minimum amount of framework, thus securing lightness with resulting ease of moving and erecting as well as security and rapidity of anchoring down.

The accompanying illustrations show various types of derrick in general use.

Pile Drivers.—The pile driver is equipped with a very substantial supporting structure and while not a hoisting rig in the general sense of the term its operation depends upon hoisting a heavy weight and may be properly considered here.

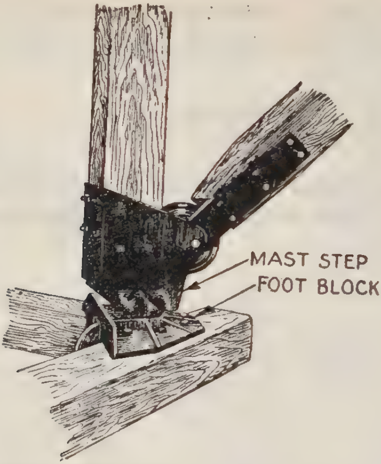
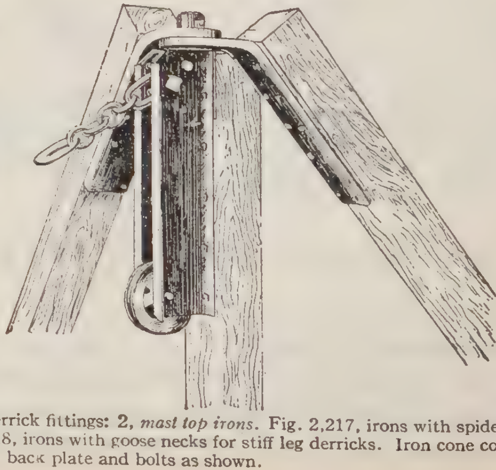
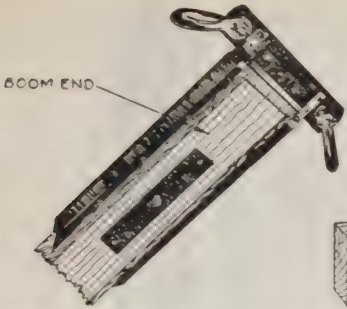
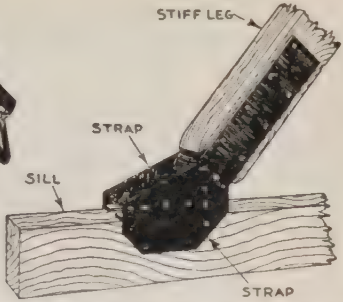


FIG. 2,216.—Derrick fittings: 1, *foot block and mast step irons*, showing lock at the rear of the ball and socket joint. There are two sheaves in the foot block and one in the mast step. The sheave in the mast step is not required for stiff leg derricks. Special foot blocks and mast steps are required for handling clam shell or orange peel buckets and other three line work.

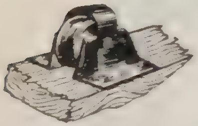


FIGS. 2,217 and 2,218.—Derrick fittings: 2, *mast top irons*. Fig. 2,217, irons with spider plate for guy derricks; fig. 2,218, irons with goose necks for stiff leg derricks. Iron cone complete with block, pin, shackles, back plate and bolts as shown.

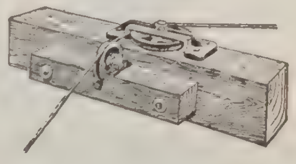




FIGS. 2,219 and 2,220.—Derrick fittings: 3, *boom end* for general work and *stiff leg connection* to sill with stiff leg straps.



FIGS. 2,221 and 2,222.—Derrick fittings: 4, *boom idler* for guy derricks and *boom end* for operating clam shell or orange peel buckets. The hole on lower side is for a shackle pin which can be used to attach upper block for a fall with several parts.



FIGS. 2,223 and 2,224.—Derrick fittings: 5, *mast brackets* used with derricks operating clam shell and orange peel buckets, and *guide sheaves* for bull wheel line.

FIG. 2,225.—View of pile driver for land pile driving showing construction of derrick and arrangement o hoisting engine and rigging. For marine use the assembly is mounted on a scow.

A pile driver consists essentially of *a hoisting engine, boiler, derrick, monkey or hammer, and rigging, all assembled on a foundation of heavy skids or on a scow.*

The supporting structure or derrick consists of an elevated structure having a pulley at the top over which passes a cable from the hoisting engine drum to the monkey or hammer, the latter working in vertical guides. In operation, when the pile is in position under the monkey, the latter is hoisted by the engine, till near the top of the derrick, when the operator releases the drum friction allowing the monkey to fall and deliver a blow to the pile.

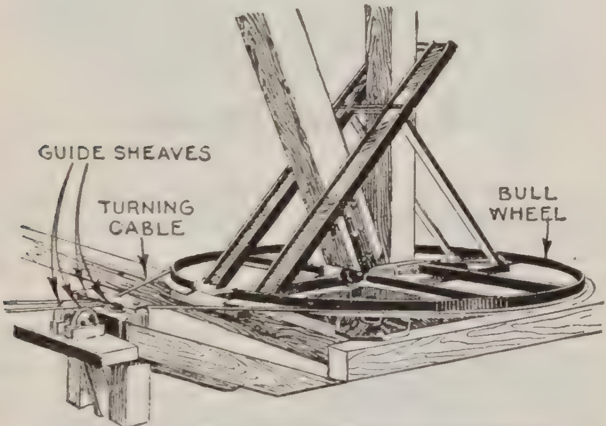


FIG. 2,226.—Derrick fittings: *6*, Terry all steel bull wheel and guide sheaves. The wheel is made in halves and may be conveniently erected without unstepping the mast. The ring is a heavy angle iron with the vertical leg rolled with an appreciable outward flare which eliminates any tendency for the line to climb. An inverted movable section of the ring is placed under the boom which makes it a full circle. The braces which drive the boom are made of steel beams, and sills of heavy angles.

The sinking of the pile depends on the character of the ground into which the pile is driven.

Piles having a diameter of 10 to 14 ins., require to be driven with a monkey weighing from 1,000 to 1,700 lbs. Sheet piles, with a breadth of 9 ins. and a thickness of 3 or 4 ins. require a 1,000 to 1,700 lbs. monkey.

The following table gives pile driver proportions as recommended by the Lidgerwood Co.

Derrick					*Monkey*
25 foot	suitable for	1,000	to	1,200	pound
30 "	" "	1,200	"	1,500	"
35 "	" "	1,500	"	1,800	"
40 "	" "	1,800	"	2,500	"
45 "	" "	2,500	"	3,000	"
50 "	" "	3,000	"	3,500	"
55 "	" "	3,000	"	4,000	"
60 "	" "	3,500	"	5,000	"

4. The Drive

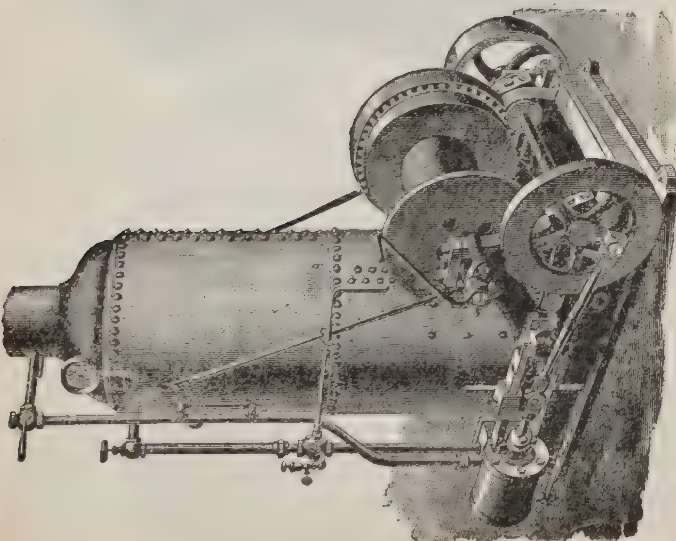
The term "drive" as here used relates to *the kind of power applied to the hoisting apparatus, as hand, steam, electric, etc.*

The mechanical arrangement for hand power has already been covered and need not be further considered.

In the so called "power" drives, the apparatus including the prime mover, gearing and drum or spool is usually combined in one unit and will here be considered briefly as a whole.

Steam Hoists.—The steam hoisting engine represents a class of machinery possessing wide utilities, and has been highly developed by manufacturers to meet the varied requirements of all kinds of building work. A so called "hoisting engine" consists essentially of a boiler, engine, transmission, and friction drum, all assembled on one base forming a unit.

Figs. 2,227 and 2,228 show single and double cylinder hoists respectively. Evidently the single cylinder type is suitable for light duty and the double cylinder, for heavy duty hoisting.



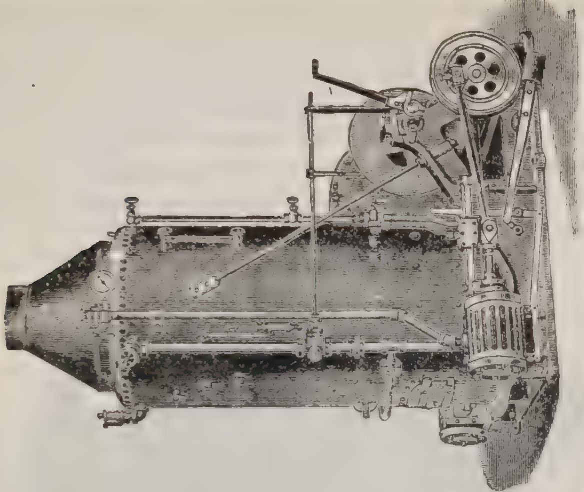


FIG. 2,227.—A single cylinder hoisting engine with geared transmission. For ordinary work it is well adapted, but for heavy duty two cylinders are preferable.

FIG. 2,228.—A two cylinder hoisting engine. The cranks being at 90 degrees there are no dead centers, thus giving better control with heavy loads

In operation, the power of the engine is applied in hoisting by means of a cable, fastened to the drum, the latter usually being loose on the engine shaft, and made to turn in applying the power by means of a friction clutch. The transmission of power between engine and drum may be by direct drive as in fig. 2,229 for high speed hoisting, or by gearing as in figs. 2,227 and 2,228, for heavy duty. The general proportions of steam hoists are given in the following table:

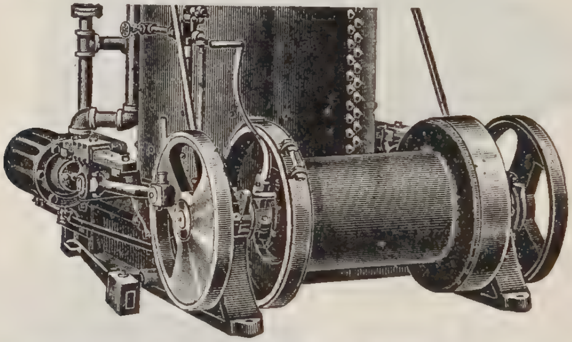


FIG. 2,229.—Simple hoisting engine with direct drive. There are two slide valve engines with cranks at right angles, hence, the engine will start in any position. This type is adapted to high speed hoisting, as in unloading coal at docks.

Twin City Double Cylinder Steam Hoist One Friction Drum with Boiler

Hoisting capacity single line	Rated H. P.	Cylinder sizes		Drum sizes		Boiler			Shipping weight approx.
		Bore	Stroke	Diam. body	Length between flanges	Diam. shell	Height shell	No. 2″ flues	
4,000	20	6¼	8	12	23	36	75	60	6,300
5,000	25	6¼	10	14	26	38	84	68	7,600
6,500	35	7	10	14	26	40	90	85	7,800
9,000	45	8½	10	14	27	42	96	92	9,500
14,000	65	10	12	16	32	54	102	150	17,000

The proportions given in the table are suitable for general work and pile driving where one drum is sufficient.

Drums.—Of the many types of drum there are two general classes: the *fixed*, and the *loose* drum. The fixed drum is found on some of the simpler machines designed for that class of work which requires only the operations of lifting or lowering, or where only single loads have to be handled.

The loose drum is the type mostly used and is so constructed that it may be thrown in, and out of engagement while the engine is in motion, by the action of *friction rings*.

Fig. 2,230 shows the principle of operation.

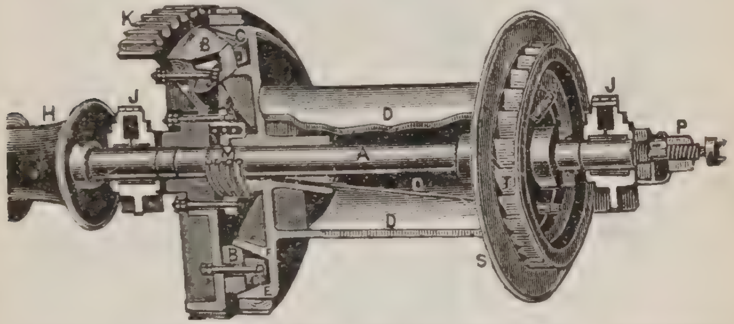


FIG. 2,230.—Sectional view of loose drum. ***The parts are:*** A, shaft; B, friction blocks; C, friction flange; D, drum; E and F, friction rings; H, winch head or spool; J, J, bearings; K, gear wheel; P, thrust screw; S, drum flange; T, ratchet teeth.

The drum D, is thrown into gear by a slight endwise movement on its shaft A, produced by turning a lever attached to the screw P, whose end is in contact with a hardened *thrust pin*. The action of this pin is best seen in the sectional view, fig. 2,231. When the engineer turns the friction lever toward him, the thrust screw, which has a left-hand thread, pushes the thrust pin against a collar key, which works in a slot cut through the shaft. The collar key, together with the collar, is in turn, pushed against the drum, forcing it into contact with friction blocks to prevent any rotation on the shaft. These blocks consist of sections of hard wood B, bolted to the gear wheel K, which is keyed to the shaft. The adjacent flange on the drum has inclined rings E, F, which register with the bevel on the friction blocks, the endwise movement given the drum by turning the friction lever, bringing the rings into frictional contact with the blocks, thus

preventing the drum turning on the shaft since the latter is keyed to the gear wheel K.

When the friction lever is turned clockwise to release the drum, the latter is pushed to the right out of engagement with the friction blocks by the spring M, allowing the drum to revolve freely on the shaft.

Loose drums are usually fitted with band brakes in order to reduce the wear on the friction blocks. This is especially de-

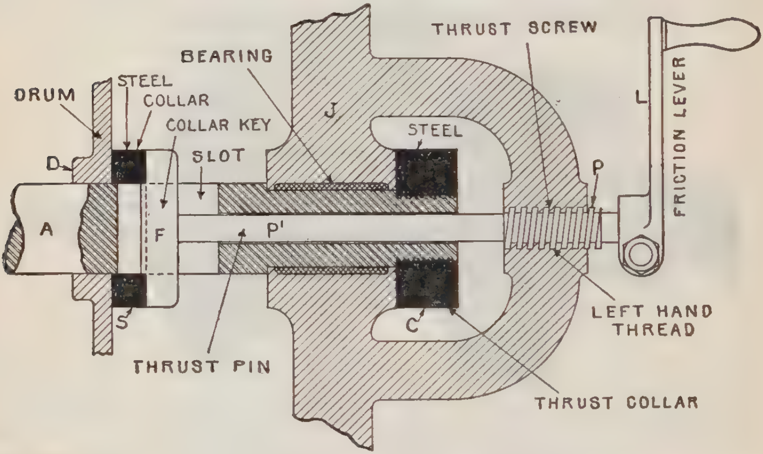


FIG. 2,231.—Sectional view of friction control on loose drum. When the friction lever is turned counter-clockwise, the left hand friction screw pushes the thrust pin to the left. The pin in turn pushes the collar key, collar, and drum in the same direction causing the latter to engage with the friction blocks.

sirable for long descents, as in tall office building construction, the wear and heat generated are excessive.

Sometimes radial ribs are placed at the friction end of the drum to assist in dissipating the heat, by presenting additional surface for radiation, and inducing air currents.

Foot Brakes.—When there is a winch head or spool, it is

necessary to have a band brake if the spool is to be used at the same time that the load is hanging on the drum. Fig. 2,232 shows the usual type of brake which consists of a metal band lined with hardwood segments, and embracing the external circumference of the drum flange.

The brake is operated by the foot, and, as shown, is of the differential type in which both ends of the band are pivoted to the rocker, but at

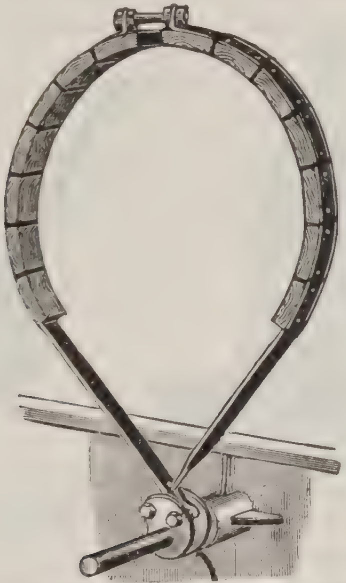
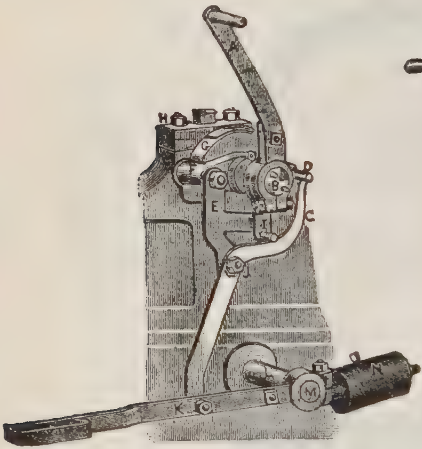


FIG. 2,232.—Band brake for holding the drum with load when disengaged from the friction. The metal band lined with hardwood segments tightly embraces the circumference of the drum when the brake lever is pressed down.

different distances from the center of the brake shaft, so that the strain brought by the load held, tends to turn the rocker in the direction to tighten the brake. By crossing the ends of the band at the rocker, the rotation of the brake shaft is limited, so that the foot lever, when released, cannot be lifted by its counterweight above a fixed and convenient position.

Electric Hoists.—In some cases, electricity is more conveniently used than steam for operating hoists. *An electric hoist is virtually the same as a steam hoist with the boiler and engine omitted and an electric motor substituted with suitable gearing and control.*

How to Operate a Hoist.—*Directions for double drum boom swinging hoist* (fig. 2,235)—The engineer first throws in the



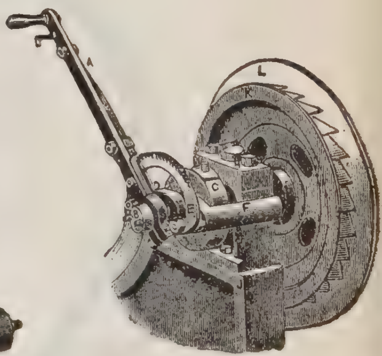


FIG. 2,233.—Lidgerwood brake and friction levers with safety attachment. When the friction lever A, is moved to throw the drum into gear, the pin I, on a projection of the friction lever presses against the curved part of the oscillating lever C, and releases the foot brake.

FIG. 2,234.—Friction lever on hoisting drum; a latch and quadrant hold the drum in any position.

NOTE.—***Capacity of Hoisting Engine.***—The horse power required to raise a load at a given speed is equal to

$$\frac{\textit{gross weight in lbs.} \times \textit{speed in feet per minute}}{33{,}000}$$

To this there should be added from 25 to 50 per cent for friction, contingencies, etc. The gross weight includes the weight of the cage, load, and rope. In a shaft with two cages balancing each thus, the net load is taken.

front friction drum lever sufficiently to hoist the load. He is then free to handle the boom, either raising or lowering it with the rear drum.

When lowering the boom, he should do it both by the friction lever, and a slight pressure on the foot brake. This prevents the oscillating lever falling into place and locking the brake; it also allows control over the lowering speed of the boom, and as soon as it is lowered far enough, then, full pressure is put on the brake lever, and the friction lever thrown out, when the oscillating lever falls into place and locks the brake fast. This use of the two levers in combination for lowering the boom provides against the possibility of the foot slipping off the foot brake.

It is important that the engineer keep the safety lever locked to the foot brake, and also the pawl applied at all times whcn the boom drum is not in use. The only exception to this rule is when working with a short boom and the time required to throw in the pawl is too valuable to lose. In such cases, the safety lever locked to the foot brake performs all that is required of the pawl and ratchet.

Double Drum Boom Swinging Hoist.—The multiplication of drums is a feature in the development of the hoisting engine adapting it to service of a universal character, such as the working of a radial derrick where frequently several operations have to be performed at the same time. An example of hoist adapted to this class of work is shown in fig. 2,235.

The forward drum is for hoisting the load, and the other for raising the boom. Between the drums and winch heads are two spools for the derrick swinging ropes. With this arrangement, the operations of hoisting the load, raising and swinging the boom can go on simultaneously.

The winch heads are secured to the shaft by a sliding key having a sleeve upon which the swinging spools revolve.

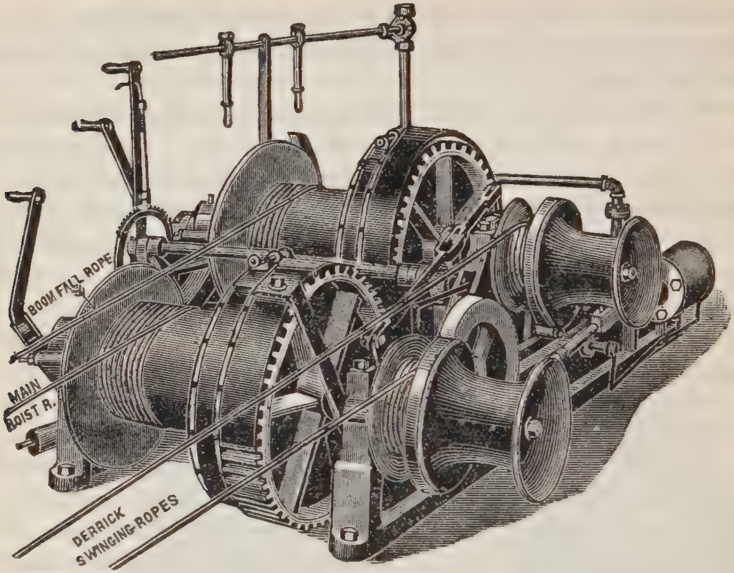


FIG. 2,235.—Double drum hoist with boom swinging gear for operating a radial derrick. The machine is so constructed that the operations of hoisting the load, raising and swinging the boom may go on simultaneously. ***In operation,*** a rope is wound on the bull ring of the derrick and secured to the same in the center, as shown in fig. 2,236. Each of the two ends is fastened to one of the two swinging spools, enough rope being wound on each to give the required amount of motion to the bull wheel. By throwing the lever forward, it engages the friction clutch on that winch, causing it to rotate and wind in the rope, which turns the boom in one direction, the other winch meanwhile paying out the rope. The construction of the cams permit this, as the same movement which engages one friction, disengages the other. By throwing the lever backward, the friction of the rear spool is engaged, and the forward spool released. Thus, the boom can be turned in either direction. The cams operating the frictions are so constructed that when the operating lever is in its central position, there is enough frictional contact in the swing spools to keep the ropes taut; therefore, when one spool is winding in the swinging rope, the other has sufficient friction to prevent the rope, which is paying out, overrunning.

NOTE.—The use of the safety lever locked to the foot brake is desirable with a long springy boom, in chaining or dogging rock after a blast, at which time it may not be known whether the rock, which it is intended to hoist, is free.

The effect of applying the strain for hoisting the rock is to spring the boom, and if the dogs fly loose, or the chain break, the boom springs back to its normal position, slackening for an instant the boom fall rope, which may throw out the pawl causing the boom to fall.

Friction adequate for the full power of the engine is used between the swinging spools and the winch heads. The frictional contact is produced by cams placed between the swinging drums and the frame of the engine; on the other side are anti-friction collars to take up the thrust.

The operating cams are connected by links to the end of a

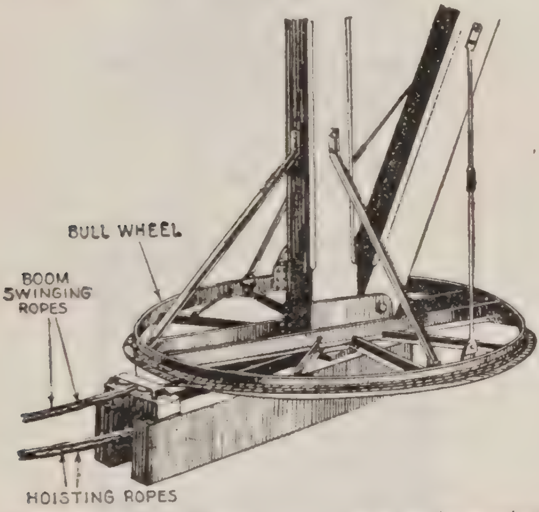


FIG. 2,236.—Base of a radial derrick, showing the bull wheel and boom swing ng ropes, also the ropes for hoisting and raising the boom.

lever, which is carried on a shaft extending across to the side where the engineer stands, and where the vertical detent lever for operating the swinging device is placed.

The brake and friction levers for the drums are shown in figs. 2,233 and 2,234.

The friction lever of the rear drum, as shown in fig. 2,233, has an extension piece 1 with a pin, which moves upon the curved surface of an oscillating lever C. The latter has a notch

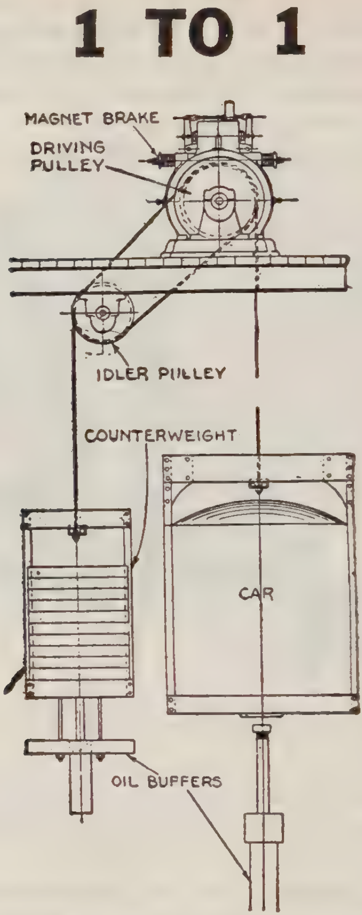


FIG. 2,237.—Diagram of Otis overmounted 1 to 1 traction elevator. The machine consists essentially of a motor, a traction driving pulley, and a magnetically released spring applied to brake, compactly grouped and mounted on a continuous heavy iron bed. The motor is of the slow speed shunt wound type. The drive from the armature spider to the pulley is effected through a flange integral with the spider and bolted directly to the pulley, thus eliminating tortional strains on the shaft and the use of keys.

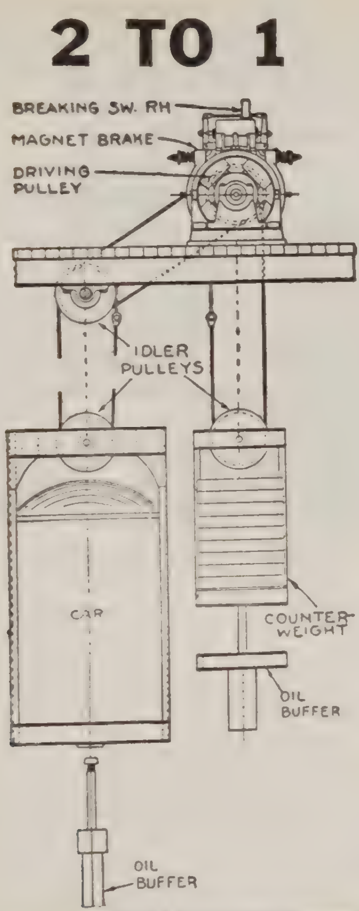


FIG. 2,238.—Diagram of Otis, overmounted 2 to 1 traction elevator. This machine is similar in appearance to the standard drum machine, except that a multi-grooved driving pulley is mounted in place of the drum, and a non-vibrating idler leading pulley takes the place of the vibrating pulley necessary on the drum type. The car and the counter-balance weight hang directly from the driving pulley, one from either end of the cables in precisely the same manner as with the 1 to 1 drive, the necessary amount of traction being obtained by the extra turn of the cables resulting from passing around the idler pulley.

at the lower end, engaging with a pin extending from the side of the foot brake lever. When the friction lever is moved, for the purpose of throwing the drum into gear, the pin on the end of the friction lever presses against the curved part of the oscillating lever and releases the foot brake.

The friction lever of the front drum, as shown in fig. 2,234, is arranged with a thumb latch and detent engaging with serrated teeth in a quadrant by which the lever is held in any desired position. The drum is thus securely locked, so that hoisting may go on without any further attention to this lever.

When the lever is moved back, the engineer places his foot on the foot brake lever for a moment and the oscillating lever drops back into its original position, engaging with the pin on the foot brake lever, and thereby locking the brake on the drum. It will be seen that this drum, with the boom hanging from it, is locked fast by the brake, the pawl being usually applied as an additional safeguard.